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Draft

Analytical Tools Inventory and Executive Descriptions

Prepared for:

CALFED Bay-Delta Program
1416 9th Street, Suite 1155
Sacramento, CA 95814

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D-003356

Resource Category/Tool	Tool Description	Full Description Enclosed	Contact	Agency	Phone
Reservoir and Delta Operations					
PROSIM	CVP and SWP system simulation (excluding the Friant Division)	Yes	Derek Hilts	Reclamation	916-978-5124
DWRSIM	SWP and CVP system simulation	Yes	George Barnes	DWR	916-653-5924
EBMUDSIM	Simulates flow and reservoir storage in East Bay Municipal Utility District Mokulmne supply facilities	Yes		EBMUD	
SANJASM	Simulates flow and storage in San Joaquin basin (Millerton Lake to Delta)	Yes	Peggy Manza	Reclamation	916-978-5124
Delta SOS	Delta standards model for simulation of effects of Delta flow standards on CVP and SWP operations		Russ Brown	JSA	916-737-3000
STANSIM	Simulates surface water flow in Stanislaus River (now included in DWRSIM)	Yes	Bill Smith	DWR	916-653-6079
HEC-2	River Hydraulic Simulation for depth and velocity vs. flow		Vern Bonner	COE	916-756-1104
TRIBSIM Series	Simulates surface water flows, reservoir operations, and diversions in tributary streams		Russ Brown or Ben Everett	JSA or CH2M-Hill	916-737-3000
DWR Consumptive Use/Depletion Model	Estimates total consumptive use in Sacramento and San Joaquin river basins to provide boundary conditions for DWRSIM or PROSIM	Yes		DWR	
River Hydraulics					
WQRRS (SHP)	Simulates river hydraulics		Mark Dortch	COE	601-634-3517
HEC-RAS	Simulates river hydraulics	Yes	Vern Bonner	COE	916-756-1104
FLDWAV	Simulates river hydraulics (replaces DWOPER, DAMBRK, and NETWORK)	Yes	Shawn Mayr	DWR	

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DWR/RMA (-2,-4,-10)	Simulates water surface elevation and velocity patterns at fine resolution	Yes	Shawn Mayr	DWR	
Watershed Hydrology and Water Budgets					
HSPF	Continuous rainfall-runoff and water quality	Yes		EPA	
PRMS	Continous rainfall-runoff	Yes		USGS	
CUDACOMP	Linked consumption use/depletion analysis model for input to DWRSIM	Yes	Jariq Kadir	DWR	916-653-3513
Groundwater					
RASA-CV	Simulation of ground water in Central Valley; Land subsidence	Yes	Steve Deverel	USGS	916-978-4648
RASA-CV (MODFLOW)	Simulation of ground water (RASA-CV input data with MODFLOW)		Stan Leaki	USGS	602-670-6671
CVGSM	Simulation of ground water/surface water in Central Valley	Yes	Dave Moore	Reclamation	916-978-4902
SANTUCM	Simulation of ground water/surface water in San Joaquin and Tulare basins	Yes	Nigel Quinn	USBR/LBNL	916-979-2325
HEM,Hydrologic-Economic Model of the San Joaquin Valley	San Joaquin basin hydrologic budget; Estimate ground water recharge	Yes	Paul Romero	DWR- Fresno	209-445-5353
Sacramento Valley Ground Water Model	Simulation of ground water in the Sacramento Valley	Yes	Glenn Pearson	DWR	916-529-7300
FSASIM	Simulation of ground water/surface water in Friant Service Area		Chuck Howard	Reclamation	916-978-4902
Western San Joaquin Ground Water Model	Simulation of ground water in Western San Joaquin Valley using MODFLOW	Yes	Steve Phillips	USGS	916-978-4648

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KBGWAM	Simulation of ground water in Kern County		Joanne Kipps	DWR	209-445-5210
SVGSM	Couples simulation of daily ground water-surface water interaction, and daily reservoir/stream system operation.		Matt Zidar	MCWRA	408-755-4860
SNGSM	Simulates ground water/surface water in Sacramento County		Cort Abney	Sac County	916-440-8230
ARGSM	Simulates ground water/surface water in Placer and Sutter Counties		Don Jacobs	City of Sacramento	916-433-6275
SJGSM	Simulates ground water/surface water in San Joaquin and Southern Sacramento Counties		T. Dudley	DWR	916-322-7164
Stony Creek Fan Ground Water Model	Simulation of ground water in Stony Creek Fan		Glenn Pearson	DWR	916-529-7300
Fresno Ground Water Model	Simulation of groundwater in Fresno Area		Steve Phillips	USGS	916-978-4648
Aerojet Ground Water Model	Simulation of ground water in eastern Sacramento County		Cindy Caulk	Aerojet	916-355-2590
Panoche Fan Ground Water Model	Simulation of ground water in the Panoche Fan Area	Yes	Steve Phillips	USGS	916-978-4648
Kesterson Ground Water Model	Simulation of ground water in the Kesterson area	Yes	Rick Mandel	USGS	916-978-4650
San Joaquin County Ground Water Model	Simulation of ground water in the San Joaquin County		Fritz Carlson	CH2M HILL	916-243-5831
MODFLOW	Simulation of ground water in Central Valley; Land subsidence	Yes	Steve Deveral	USGS	916-978-4648
IGSM	Simulation of ground water/surface water in Central Valley	Yes	Chuck Howard	USGS	916-978-4902
Transient 3-d Ground Water Flow Model	Simulates hydraulic heads in central part of western San Joaquin Valley	Yes	Ken Blitz	Dartmouth University	603-646-3365

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FLOW3D	Finite-element, finite difference, 3-dimensional groundwater simulation model	Yes	Linda Bond	Hydrologic Consultants, Inc.	916-756-0925
eXterra (Central)	Groundwater elevation data base for Contra Costa, San Joaquin, Sacromento, Solano, Yolo, Sutter, Yuba, Placer, Nevada, El Dorado, Napa, Sonoma, and Mendocino counties	Yes	Eric Senter	DWR	916-227-7571
eXterra (North)	Groundwater elevation data base for Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Shasta, Lassen, Tehama, Plumas, Butte,Glenn, Colusa, Lake, Mendocino, and Sierra counties	Yes	Pat Huckabay	DWR	916-529-7314
Bay-Delta Tidal Hydrodynamics and Salinity					
Fischer Delta Model (V. 7)	1-Dim. simulation of Bay-Delta flow and salinity transport	Yes	Henry Wong	Reclamation	916-978-4923
Fischer Delta Model (V. 10)	1-Dim. simulation of Bay-Delta flow and salinity transport	Yes	Greg Gartrell	CCWD	510-674-8057
Link-Node Model - Delta	1-Dim. simulation of Delta flow and salinity transport		Don Smith	RMA	510-284-9071
Link-Node Model - Bay/Delta	1-Dim. simulation of Bay-Delta flow and salinity transport		Don Smith	RMA	510-284-9071
Link-Node Model - South Delta	1-Dim. simulation of South Delta flow and salinity transport		Gerald Orlob	UC Davis	916-752-1424
RMA-2 Delta/Sac Rv.	2-Dim. vertically averaged model used in simulation of Delta/Sac Rv.		Don Smith	RMA	510-284-9071
RMA-4Q	Simulation of estuary water quality (conservative parameters)		John DeGeorge	UC Davis/RMA	916-752-6300
USBR Hydrodynamic Model	1-Dim. simulation of Bay-Delta flow and salinity transport		Henry Wong	Reclamation	916-978-4923
Link-Node Model - Suisun Marsh	1-Dim. simulation of Suisun Marsh flow and salinity transport		Don Smith	RMA	510-284-9071
Four Point/BLTM	1-Dim. hydrodynamic and transport model of the Delta		Francis Chung	DWR	916-653-5601

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RMA-10 Bay/Delta	3 dim. finite element hydrodynamic model of Delta and San Fran. Bay		Ian King	UC Davis	916-752-8386
ADI Hydrodynamic Model	2-Dim. simulation of San Francisco Bay		Pete Smith	USGS	916-978-4648
SPECTRAL	2-Dim. Finite Element Tidal simulation model of San Fran. Bay		Jon Burau	USGS	916-978-4648
TRIM2D	2-Dim. Tidal Residual Intertidal Mud Flat Model (San Fran. Bay)	Yes	Ralph Cheng	USGS	415-354-3358
TABS2	2-Dim. Finite Element hydrodynamic simulation model of San Fran. Bay		Pete Smith	USGS	916-978-4648
2 Dim. X-Z Model	2-Dim. Finite Difference simulation model of San Francisco Bay		Pete Smith	USGS	916-978-4649
EHSM3D	3-Dim. Estuarine Hydrodynamic Software Model (San Fran. Bay)	Yes	Ralph Cheng	USGS	415-354-3358
ECOM-si	3-Dim. Semi-Implicit hydrodynamic model (San Fran. Bay)		Ralph Cheng	USGS	415-354-3359
TRIM3D	3-Dim. Tidal Residual Intertidal Mud Flat Model (San Fran. Bay)		Ralph Cheng	USGS	415-354-3358
Continuous velocity and water quality data, Suisun Bay	3-d distribution of velocity (Doppler), salinity, chlorophyll, turbidity in Suisun Bay	Yes	Ralph Cheng	USGS	415-354-3358
HYDSAL	1-Dim. Flow and Salinity Transport model (Suisun Marsh)		Paul Crapuchettes	Private Consultant	707-864-8548
Uncles/Peterson Model	1-Dim. Intertidal Hydrodynamic and salinity transport model	Yes	Noah Knowles	Scripps Institute	
DWR-DSM2	1-Dim. Hydrodynamic and Water Quality model	Yes	Francis Chung	DWR	
DWR-DSM,Suisun Marsh	Hydrodynamics and water quality model for Suisun Marsh	Yes	Francis Chung	DWR	

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CCWD Salinity Outflow Model (G Model)	1-Dim. Hydrodynamic and salinity transport model	Yes	Richard Denten	CCWD	510-688-8187
X2 Equations	Empirical relationships between daily or monthly 2% isohaline and Delta outflow		Wim Kimerer	SFSU	
River and Reservoir Temperature					
Upper Sac. River Model (QUAL-2E)	Simulates Sacramento River temperature		Gerald Orlob	UC Davis	916-752-1424
CE-QUAL-R1 - Folsom	Daily reservoir temperature profile and release temperatures		Jack Humphrey	Hydmet	916-547-3403
CE-QUAL-R1 - Shasta	Daily reservoir temperature profile and release temperatures		Mark Dortch	COE	601-634-3517
WQRRS-Shasta	Simulates river water quality		Jack Rowell	Reclamation	916-978-4923
WQRRS-Clair Engle	Simulates river water quality		Gerald Orlob	UC Davis	916-752-1424
WQRRS-Stanislaus	Simulates river water quality		Don Smith	RMA	510-284-9071
RMA-6-Lewiston/Keswick	Daily reservoir temperature 2-D patterns and release temperatures		Gerald Orlob	UC Davis	916-752-1424
Sacramento Basin	Monthly reservoir profiles, releases, and river temperatures for entire Sacramento Basin		Jack Rowell	Reclamation	916-978-4923
Upper Sacramento River	Daily river temperatures between Keswick and Red Bluff		Jack Rowell	Reclamation	916-978-4923
Stanislaus Basin	Monthly New Melones temperature profile and release temperature and Stanislaus temperatures		Jack Rowell	Reclamation	916-978-4923
QUAL-2E- Lower American River	Simulation of Temperature - Lower American River		Jack Humphrey	Hydmet	916-547-3403

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QUAL-2E-Sacramento and American Rivers	Simulation of Temperature - Sacramento and American Rivers		Jack Humphrey	Hydmet	916-547-3403
QUAL-2E-Feather River	Simulation of Temperature - Feather River		Jack Humphrey	Hydmet	916-547-3403
QUAL-2E-Bear River	Simulation of Temperature - Bear River		Jack Humphrey	Hydmet	916-547-3403
Yuba-Bullards Bar	Daily reservoir temperature profile, release, and river temperatures		Don Wilson	YWCA	916-741-6278
BETTER-Lewiston	Daily reservoir temperature 2-D patterns and release temperatures		Tom Stokely	Trinity Co.	916-623-1351
BETTER-McClure	Daily reservoir temperature 2-D patterns and release temperatures (under development)		Russ Brown	JSA	916-737-3000
SNTEMP-Trinity	Steady state river temperatures for specified meteorology		Mike Aceituno	Service	916-978-4613
SNTEMP-Yuba	Steady state river temperatures for specified meteorology		Jim White	DFG	916-653-3540
SNTEMP-Mokelumne	Steady state river temperatures for specified meteorology		Jim White	DFG	916-653-3540
SNTEMP-Tuolumne	Steady state river temperatures for specified meteorology		Peter Fritz Baker	EA	415-283-7077
SNTEMP -Feather River	Steady state river temperatures for specified meteorology		Randy Brown	DWR	916-322-7165
STREAM-Merced	Hourly river temperatures with daily flow variations		Russ Brown	JSA	916-737-3000
Agricultural Drainage Water Quality					
WADE	Seasonal ground water flow and salt balance optimization	Yes	Nigel Quinn	USBR/LBNL	916-979-2325

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HYSAM	Monthly water and salt (minerals) balance for cropland	Yes	Fawsi Karajeh	DWR	916-327-1828
Rice Herbicide Reduction Monitoring Program	Herbicide monitoring in canals and mainstem reaches of upper Sacramento R basin, 1985-1993	Yes	Rudy Schnagl	SWRCB-Sac	916-255-3101
IRDROP	Monthly ground water flow and salt balance optimization	Yes	Nigel Quinn	USBR/LBNL	916-979-2325
SJRIO-2	Monthly surface and groundwater quality for San Joaquin River	Yes	Les Grober	CRWQCB	916-255-3105
SJRIO-DAY	Daily surface and groundwater quality for San Joaquin River (replaces SJRIO-2)	Yes	Les Grober	CRWQCB	916-255-3105
National Resources Workstation (NRWS)	Simulates flow and water quality of wetland storage operations using GIS (GRASS) and HEC-5Q models	Yes	Nigel Quinn	USBR/LBNL	916-978-5039
SJRMOD	Salt mass balance for lower San Joaquin R	Yes	Gerald Orlob	UC-Davis	916-752-1424
DICU	Delta Island Consumptive Use model calculates channel depletion, Delta island diversions, and drainage amount and quality.	Yes	Francis Chung	DWR	916-653-5601
SWAGSIM	Soil and groundwater quality simulation	Yes	Jim Ayars	USDA	209-453-3100
River and Delta Water Quality					
DeltaDWQ	Monthly flow, salt, and dissolved organic carbon balance for Delta	Yes	Russ Brown	JSA	916-737-3000
THM Formation Potential Model	Tracks THM formation potential (DOC) in the Delta	Yes	Francis Chung	DWR	916-653-5601
WASP4	Simulation of estuarine and riverine water quality	Yes	Catherine Green	EPA	404-546-3210
Delta Water Quality Surveillance Program	Documents water quality conditions at 28 stations, 1975-present	Yes	Harlan Proctor	DWR-Sacramento	916-227-7551

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National Stream Quality Accounting Network	Documents water quality for Sacramento R at Keswick and Freeport and for San Joaquin R at Vernalis, 1975-1995.	Yes	Neil Dubrovsky	USGS-Sacramento	916-979-2615
SWP Water Quality Monitoring Program	Documents water quality conditions at 33 sites in State Water Project system, 1968 to present	Yes	Larry Joyce	DWR	916-653-7213
Toxic Substances Monitoring Program	Documents tissue burden of trace metals and synthetic organic compounds in fish and other aquatic organisms at many sites in Central Valley and Bay-Delta, 1978-present	Yes		SWRCB	
SF Estuary Regional Monitoring Program for Trace Substances	Contaminants (e.g., pesticides) sampled at up to 24 Bay-Delta stations in water, sediments, and transplanted bivalves.	Yes	Bruce Thompson	SFEI	510-231-9539
SBDA Water Quality Monitoring Program	Documents water quality at 24 sites in South San Francisco Bay, 1980-1985.	Yes			
Daily sediment discharge data	Daily suspended sediment load for Sacramento R at Freeport and San Joaquin R at Vernalis, 1957-present		Neil Dubrovsky	USGS-Sacramento	916-979-2615
Link-Node Model - Stockton Ship Ch.	1-Dim. simulation of Stockton Ship Channel flow, salinity, temperature, DO.	Yes	Don Smith	RMA	510-284-9071
Municipal Water Quality Investigations (MWQI) Program	Monthly water quality data (sodium, asbestos, THMs, pesticide residues, etc.) for 17 Delta channel and 3 agricultural drain sites	Yes	Rick Woodward	DWR	916-327-1636
WTP	Water treatment plant simulation model			EPA	
THM-C12	Estimates THM concentration from DOC, Br, and Chlorine dose data		Russ Brown	JSA	916-737-3000
ANN-THM formation potential model	Simulates THM formation potential using artificial neuron network model	Yes	Paul Hutton	DWR	916-653-5666
Riparian Habitat and Wildlife					
Habitat Quality Models	Evaluation of habitat type that may support several species		Steve Holl	JSA	916-737-3000
NDDB	California Natural Diversity Data Base documents occrrences of special status plant and animal species and special status communities	Yes		Natural Heritage Div, DFG	

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Wetland Habitat and Wildlife					
USFWS Wetland Maps	GIS coverage of wetland types using 1:24,000 base maps				
Central Valley Wetland Habitat Maps	GIS coverage of wetland types from LANDSAT imagery.			Pacific Meridian	
Bay-Delta Wetland Habitat Maps	GIS coverage of Bay and Delta		Josh Collins	SFEI	
Aquatic Habitat					
Salmonid flow/habitat indices	Estimates the effects of flow conditions on salmonid habitat under different simulated flow regimes in the Sacramento-San Joaquin basin.	Yes	Warren Shaul	JSA	916-737-3000
Salmonid habitat restoration indices	Estimates the effects of habitat restoration on habitat conditions for salmonids in reaches within the Sacramento-San Joaquin basin.	Yes	Warren Shaul	JSA	916-737-3000
Habitat Suitability Indices (HSI)	Estimates the suitability of a given habitat for a given fish species based on habitat variables	Yes		Service-Sacramento	
PHABSIM	Habitat/flow relationship models - developed for numerous rivers in the study area by DFG, DWR, & Service		Jim White	DFG/DWR	916-653-3540
Redd dewatering	Predicts redd dewatering based on stage-discharge relationships and spawning habitat use		Bill Mitchell	JSA	916-737-3000
Salmonid stranding	Stranding based on flow - Mokelumne River and Tuolumne Rivers		Warren Shaul	JSA	916-737-3000
Primary and Secondary Production					
HYDROQUAL Phytoplankton Model	Simulates phytoplankton dynamics in San Francisco Bay estuary	Yes	Peggy Lehman	DWR	916-227-7551
NASQAN	Abundance (cells/mL) and taxonomic composition (genus) of sestonic algae in monthly samples collected in Sacramento and San Joaquin rivers, 1976-1981	Yes	Neil Dubrovsky	USGS	916-979-2615

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IEP-Phytoplankton monitoring data	Abundance (cells/mL) and taxonomic composition (genus) of phytoplankton at numerous Bay-Delta sites, 1975-present		Peggy Lehman	DWR	916-227-7551
Neomysis/Zoo-plankton Project	Abundance of *Neomysis mercedis* and zooplankton at 35 Bay-Delta sites, 1968-present	Yes	James Orsi	CDFG	209-942-6087
Delta Outflow/San Francisco Bay Study	Open water and shoreline monthly sampling for fish, shrimp, and crabs, 1980-present	Yes	Kathryn Hieb	CDFG	209-942-6078
Entrainment and Fish Movement					
Delta MOVE	Predicts variability in production of juvenile fish based on distribution by flow and losses to diversions		Warren Shaul	JSA	916-737-3000
Entrainment loss/mortality	Various models which predict entrainment loss/mortality in diversions from the Sacramento River		Warren Shaul	JSA	916-737-3000
Chinook Salmon/Striped Bass Survival (Delta)	Regression models of survival on temperature, flow, and export - Sacramento River/Delta		Marty Kjelson and Don Stevens	Service/DFG	209-946-6400
Delta fish transport indices	Estimates the potential movement of fish eggs and larvae from spawning habitat to rearing habitat for a given set of Delta conditions.	Yes	Warren Shaul	JSA	916-737-3000
Salmonid diversion indices	Estimates losses on salmonid populations resulting from water diversions in the Sacramento-San Joaquin basin	Yes	Warren Shaul	JSA	916-737-3000
Delta diversions indices	Estimates losses on screenable life stages of striped bass, Delta smelt, longfin smelt, Sacramento splittail, American shad, and green and whit sturgeon populations from water diversions in the Delta	Yes	Warren Shaul	JSA	916-737-3000
Particle Tracking	Particle tracking for the Delta - linked with DWRDSM hydrodynamics model		Francis Chung	DWR	916-653-5601
Anadromous Fish					
Bay-Delta Fish Abundance	Regression models predict variability in population abundance based on Delta outflow and exports		Randy Baxter	DFG	209-942-6081
Chinook salmon harvest	Predicts harvest by age cohort - Pacific Ocean		Allen Boracco	DFG/NMFS	916-355-7098

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Chinook salmon survival	Survival and growth relationships for eggs and juveniles		Jack Rowell	Service/ Reclamation	916-978-4923
American shad distribution	Regression of distribution of virgin spawners on tributary flow proportion - Sacramento River Basin		Jim White	DFG	916-653-3540
CPOP - 2 (Fall-run Chinook Salmon)	Predicts variability in population abundance based on variable biological, chemical and physical factors	Yes	Jim White	DFG/NMFS	916-653-3540
CPOP - W (Winter-run Chinook Salmon)	Predicts variability in population abundance based on variable biological, chemical and physical factors		Gary Stern	NMFS	707-578-7513
Chinook salmon population	Predicts equilibrium ocean harvest based on spawner-recruit relationships and Delta survival - Sacramento River Basin		Randy Brown	DWR	916-322-7165
Chinook salmon survival	Survival and growth relationships for eggs and juveniles		Warren Shaul	JSA	916-737-3000
Smolt emigration	Regression of peak smolt emigration timing on flow - Yuba River		Bill Mitchell	JSA	916-737-3000
SALMOD	Fish population/habitat relationships - Trinity River		C.B. Stalnaker	Service	303-491-7767
Reservoir fisheries	Models available to evaluate effects of reservoir operations on fisheries		Warren Shaul	JSA	916-737-3000
San Joaquin Chinook salmon population model (EACH)	Simulates the dynamics of fall-run chinook salmon populations in the San Joaquin River and tributaries	Yes	Bill Johnston	EA	415-283-7077
Salmonid distribution dataset	Describes the spatial and temporal distribution of steelhead and chinook salmon in the Sacramento San Joaquin basin.	Yes	Warren Shaul	JSA	916-737-3000
Salmonid temperature indices	Estimates the survival of salmonids under different simulated temperature regimes in the Sacramento-San Joaquin basin.	Yes	Warren Shaul	JSA	916-737-3000
Bay-Delta Resident Fish					
Bay-Delta fishes distribution data	Describes the spatial and temporal distribution of several species of fishes in San Francisco Bay, the Delta, and the lower Sacramento.	Yes		CDFG	

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Overflow habitat index	Estimate the amount of flood basin inundation, which is assumed to be beneficial to Sacramento splittail spawning.	Yes	Warren Shaul	JSA	916-737-3000
Delta habitat indices	Estimates the amount of habitat within the salinity tolerance range of a number of estuarine fishes and invertebrates in the Delta.	Yes	Warren Shaul	JSA	916-737-3000
Striped Bass Population Model	Simulates age class structure for striped bass		Lou Bodsfort	UC-Davis	
Striped Bass Life Cycle Model	Striped bass life history and energetics model			U of Alabama	
Levee Failure Risk					
Seismic and Flooding Risk Assessment	Risk assessment of levee failure due to catastrophic earthquake or floods		Curt Schmute	DWR	
Power					
CVPOWER	Used to optimize CVP's long term average annual generation under various hydrological constraints	Yes	John Anderson	Western	916-649-4419
PROSYM	Production costing model for estimating power production costs and dispatching to meet peak loads	Yes	Paul Scheuerman	Western	916-929-3653
PROJUSE	Projects monthly and annual energy use of the CVP system based on varied hydrologic and regulatory scenarios	Yes		Reclamation	
Engineering Economics					
Unit Cost Estimation Method	Water resource agency standardized procedures for facilities cost estimation				
Regional Economics					
IMPLAN	Estimates total change in value of regional output, income, and employment associated with change in final demand	Yes	Doug Olsen	Minn IMPLAN Group	612-779-6638

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Central Valley Production Model (CVPM)	Predicts changes in irrigated acreage, crop production, price, value and net returns, and changes in irrigation technology from changes in costs or water supply	Yes	F. Farnam, R. Hoagland	DWR	916-653-5791
California Agricultural Resources Model (CARM)	Predicts changes in irrigated crop production from changes in costs, input prices or resource conditions such as water supply	Yes	R. Howitt, (CH2M HILL)	UC Davis	916-920-0300
Central Valley Production and Transfer Model (CVPTM)	Estimates water transfer amounts, prices, sources, and destinations		Stephen Hatchett	CH2M HILL	916-920-0300
Westside Agricultural Drainage Economics (WADE)	Combines regional farm income optimization with seasonal ground water flow and salt balance to assess drainage control policies in the Western and Southern San Joaquin Valley	Yes	Stephen Hatchett	CH2M HILL	916-920-0300
Crop Budgeting Method	Calculates net return, by crop and region, given prices for products, water and other inputs.	Yes	Gary Bedker	Reclamation	916-978-5251
Survey-Based Studies	Uses interviews or other survey techniques to elicit information from producers and district personnel.		S. Archibald	Univ. of Minnesota	612-625-5000
Horner-Dudek Model	A precursor to WADE, prepared for EPA to evaluate drainage control BMPs		Gerald Horner	Private Consultant	415-744-1500
Agro-economic model	Five region optimization model to assess water management policies in California.		Ariel Dinar	World Bank	415-744-1500
Decision Support					
Facet					
Arcview					
CALFED Performance Measures/Cost	Spreadsheet calculation and display of performance measure and cost estimates for actions included in CALFED alternatives		Lorne Vitora?	CALFED	

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Resource Category/Tool	Tool Description	Full Description Enclosed	Contact	Agency	Phone
Souther Calif. Sport Fishing TC Model	Southern California marine sport fishing TC model		Thomas Wegge	JSA	916-737-3000
California Marine Sport Fishing	California marine sport fishing economic model		Bob Rowe	Hagler-Bailly	303-449-5515
S.F. Bay seal/salmon CV Model	San Francisco Bay harbor seals/salmon CV model		Thomas Wegge	JSA	916-737-3000
Feather River TC Model	Feather River TC model		John Loomis	Colorado State University	303-491-6325
Stanislaus/San Joaquin	Stanislaus/San Joaquin River TC Model		John Loomis	Colorado State University	303-491-6325
California Ocean Salmon Sport Fishing Model	California salmon ocean sport fishing use-estimation model		Chris Dumas	UC-Berkeley	510-642-2548
Sacramento River Sport Fishing TC Model	Sacramento River and tributaries sport fishing travel cost model		Brian Roach	UC Davis	916-752-6182
Municipal and Industrial Water Economics					
Economic Risk Model	Estimates cost of new water supplies from SWP compared to cost of water shortages and other supply sources.	Yes	Ray Hoagland	DWR	916-653-5791
Avoided Cost Method	Estimates the value of changes in water supply as the avoided cost of replacement sources.		Craig Stroh	Reclamation	916-978-5251
Alternative Cost Approach	Measures economic benefit of an action as the avoided cost of the best alternative	Yes	Stephen Hatchett	CH2M HILL	916-920-0300
Central Valley Water Municipal Use Model	Estimates the economic costs and benefits of CVPIA provisions on M&I water users	Yes	Roger Mann	CH2M HILL	916-920-0300
IRPSIM	Simulates balance of water demand and supply in Metropolitan Water District of Southern California's service area	Yes		MWD	
Agricultural Production Economics					

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Resource Category/Tool	Tool Description	Full Description Enclosed	Contact	Agency	Phone
Regional Economic Modeling System (RIMS)	Estimates total change in regional output, income, and employment caused by a change in final demand	Yes	Steve Hatchett	CH2M HILL	916-920-0300
Computable General Equilibrium Model	An econometric model (based on IMPLAN) applied to southern San Joaquin Valley		George Goldman	UC Berkeley	510-642-6000
Westlands I-O Model	A 1985 input-output model developed for the Westlands Water District		Tim Wallace	U.C. Berkeley	510-642-6000
Fish, Wildlife, Recreation Economics					
Sacramento River Bioeconomic Model	Sacramento River bio-economic model		Roger Wolcott	NMFS	707-578-7513
San Joaquin Valley Wetlands CV Model	San Joaquin Valley wetlands/river contingent valuation model		Thomas Wegge	JSA	916-737-3000
Reservoir Travel Cost Model	U.S. Army Corps of Engineers reservoir travel cost model		John Loomis	Colorado State University	303-491-6325
Sacramento River Travel Cost Model	Sacramento River TC model		John Loomis	Colorado State University	303-491-6325
Los Vaqueros TC	Los Vaqueros reservoir TC model		Nicholas Dennis	JSA	916-737-3000
SF Bay TC/CV Model	San Francisco Bay salmon/striped bass TC/CV model		Cindy Thomson	NMFS	619-546-7116
Central Valley Fish and Wildlife TC/CV	Central Valley fish and wildlife TC/CV model		Michael Hay	Service	916-978-4613
Sacramento River Salmon	Sacramento River salmon fishing valuation model		Micheal Havemann	UC Berkeley	510-841-6443
SWP Reservoir TC	State Water Project Reservoir TC model		David Mitchell	M3	916-373-1766
Wildlife Refuge TC	State/Federal wildlife refuge TC model		John Loomis	Colorado State University	303-491-6325

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Name and Resource Category: PROSIM version 5.61. Reservoir Operations Model.

Purpose: The **PRO**ject **SIM**ulation model was developed by Reclamation to simulate the CVP and SWP water systems in the northern central valley and south of the Delta. The model is designed to simulate the river flow and reservoir storage response to reservoir operations, regulatory standards, hydrologic conditions, and water demands. PROSIM incorporates these criteria and conditions and operates CVP reservoirs as an integrated unit. The model user can modify input to assess the effects of such changes on rivers and reservoirs in the model area.

Approach: PROSIM is an arithmetic accounting of hydrologic conditions within the model boundaries. The model boundaries include the Trinity, Sacramento, Feather, American, and San Joaquin Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Yuba, Bear, Mokelumne, Cosumnes, and Calaveras Rivers and numerous small tributaries, are included in the model but at a lesser level of detail.

Inputs: The input to the model includes hydrology, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow standards and Delta standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity. Data are application specific and provided to the model in separate files for each type of input. The user specifies the simulation period and current data sets extend for 70 years.

Methods: The model performs mass balance calculations at each model node to track flow, storage and other model conditions. The model nodes are approximations for physical conditions and locations. For example, the model starts with the flow into a node then subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: PROSIM produces extensive output at each model node in a binary file. Examples of output include flow, storage, diversions, deliveries, and regulatory criteria. A post processor is needed to extract the output from the binary file.

Applications: PROSIM is used to estimate conditions in the CVP and SWP service areas under different hydrologic, regulatory, or water demand conditions. The model is useful in determining the change in some condition that could result from changes in model input. The model is site specific to the CVP and SWP systems and does not analyze local water projects in detail. PROSIM can also generate data to use in the CVP power model to estimate power generation.

CALFED Potential: This model is applicable to CALFED alternatives analysis.

Documentation: There is no official documentation for the current version of PROSIM although the model is in wide use with many applications.

Availability: PROSIM is available from the U.S. Bureau of Reclamation, Mid-pacific Regional office in Sacramento, CA or from the Reclamation home page on the Internet.

Name and Resource Category: DWRSIM version 7.54. Reservoir Operations Model.

Purpose: DWRSIM was developed by the California Department of Water Resources to simulate the SWP and CVP water systems in the northern central valley and south of the Delta. The model is designed to simulate the river flow and reservoir storage response to reservoir operations, regulatory standards, hydrologic conditions, and water demands. DWRSIM operates the SWP reservoirs as an integrated unit. The model user can modify input to assess the effects of such changes on rivers and reservoirs in the model area.

Approach: DWRSIM is an arithmetic accounting of hydrologic conditions within the model boundaries. The model is an adaptation of an HEC-3 model and has been customized to simulate the SWP system. The model boundaries include the Trinity, Sacramento, Feather, American, and San Joaquin Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Yuba, Bear, Mokelumne, Cosumnes, and Calaveras Rivers and numerous small tributaries, are included in the model but at a lesser level of detail. The Stanislaus River is input as a time series developed from STANSIM or similar model.

Inputs: The input to the model includes hydrology, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow standards and Delta standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity. Data are application specific and provided to the model in separate files for each type of input. The user specifies the simulation period and current data sets extend for 71 years.

Methods: The model performs mass balance calculations at each model node to estimate several model conditions. The model nodes are approximations for physical conditions and locations. For example, the model starts with the flow into a node then subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: DWRSIM produces extensive output at each model node in a binary file. Examples of output include flow, storage, diversions, deliveries, deficiencies, and regulatory criteria. The output can be accessed directly from the model and be presented in tables or graphs

Applications: DWRSIM is used to estimate conditions in the SWP and CVP service areas under different hydrologic, regulatory, or water demand conditions. The model is useful in determining the change in some condition that could result from changes in model input. The model is site specific to the SWP and CVP systems and does not analyze local water projects in detail.

CALFED Potential: This model is applicable to CALFED alternatives analysis.

Documentation: There is no official documentation for the current version of DWRSIM.

Availability: DWRSIM is available through the California Department of Water Resources, Sacramento, CA.

Name and Resource Category: EBMUDSIM

Purpose: EBMUDSIM was developed by the East Bay Municipal Utility District to simulate flow and reservoir storage in its Mokelumne River water facilities, including the terminal EBMUD reservoirs. The model estimates flow and water storage conditions for assumed hydrologic, water demand, and reservoir operation conditions.

Approach: EBMUDSIM is an arithmetic accounting of the runoff of the Mokelumne River basin, as influenced by the EBMUD reservoirs. The model is site specific to the basin and the EBMUD terminal reservoirs (reservoirs located in the bay area).

Inputs: The input data for the model include hydrologic data, reservoir capacity and flood control criteria, water demands, instream flow requirements, and other agency considerations. The hydrologic time series available to the model covers a 70 year period.

Methods: The model performs mass balance calculations to determine flow, storage, power generation, and other model output. Hydrologic conditions at each model location are modified by diversions and losses.

Results: Model output includes EBMUD reservoir storage, Mokelumne Aqueduct flows, Lake Camanche releases, EBMUD customer deficiencies, and power generation.

Applications: The model provides data for simulating the Mokelumne River system based on EBMUD demands and operations. The model is limited in geographic extent but could be used to provide boundary conditions for other operations models that cover a larger geographic area.

CALFED Potential: Because of the site specific nature of this model, it is not applicable to the CALFED process except to provide a boundary for the Mokelumne River at the Delta.

Documentation: Currently, there is no documentation for this model.

Availability: EBMUDSIM is a proprietary model of EBMUD and is not available for public distribution.

Name and Resource Category: SANJASM. Reservoir Operations Model

Purpose: The **San** Joaquin Area Simulation Model was developed to simulate the flow and storage conditions in the San Joaquin River basin. SANJASM incorporates reservoir operations, flow standards, demands, and hydrology, and the user can modify input to assess the effects of such changes on rivers and reservoirs in the model area.

Approach: SANJASM is an arithmetic accounting of flow and storage within the model boundaries. The model boundaries include the San Joaquin, Merced, Tolumne, Stanislaus, Fresno, Chowchilla, Mokelumne, and Calaveras Rivers. These primary rivers are subdivided for model calculations and analyzed in detail. The Cosumnes River, westside streams, and numerous small tributaries, are included in the model but at a lesser level of detail. The Friant Unit is included in the model. The model was developed using historic data for a set level of development.

Inputs: The input to the model includes hydrology, water demands, regulatory criteria, and operational considerations. Hydrologic data include reservoir inflows, rainfall, evaporation, and river accretions and depletions. Regulatory criteria include instream flow standards and Vernalis water quality standards. Operational considerations include reservoir management criteria, flood control requirements, and canal or pump capacity. Data are application specific and provided to the model in separate files for each type of input. The user specifies the simulation period and current data sets extend for 70 years. Groundwater is not simulated in the model.

Methods: The model performs mass balance calculations at each model node to track flow, storage and other model conditions. The model nodes are approximations for physical conditions and locations. For example, the model starts with the flow into a node then subtracts diversions and losses, and adds water gains to estimate the flow leaving the node.

Results: SANJASM produces extensive output at each model node in a binary file. Examples of output include flow, storage, diversions, deliveries, and regulatory criteria. A post processor is needed to extract the output from the binary file. The model also calculates water quality at Vernalis, based on an flow/quality equation.

Applications: The model is used to estimate conditions in the San Joaquin, Mokelumne, and Calaveras River basins under specified hydrology and reservoir operations. The model can also be used to develop boundary conditions at the Delta.

CALFED Potential: This model can be used to simulate CALFED alternatives.

Documentation: Documentation was written when the model was developed, however, there have been changes to the model since then documentation was prepared. The model has been used in many applications.

Availability: SANJASM is available from Reclamation.

Tool & Category: **STANSIM (version Smelt-242-F from 12/15/94 Accord) Surface Water**

Purpose: To impose the standards to maintain the fish flow requirement on the Stanislaus River and meet the minimum flow requirement and water quality at Vernalis on the San Joaquin River. It does not simulate any operations on the upper San Joaquin river above the Stanislaus River.

Approach: The model operates as a mass balance, with its operations governed by the D1485 Delta Standards.

Inputs: Inputs include: beginning storage at New Melones, end of September target storage, average inflow for August and September, incremental water quality reserve, fish flow schedules, Vernalis minimum flow requirement, maximum additional New Melones release for SJR water quality, Goodwin Dam inflow, CVP lake export, and lower Stanislaus diversion.

Methods: The major components of the STANSIM model are: (1) Water is released from New Melones to satisfy fish flow requirements, according to the amount of water that is in storage. (2) If the minimum flows at Vernalis are not met, New Melones water is released (up to a maximum volume) to satisfy it. (3) If the water quality standard at Vernalis is not met, additional water from New Melones is released (up to a maximum volume). (4) Calculate the water quality at Vernalis.

Results: Outputs include: New Melones storage, salinity at Vernalis, actual flow at Vernalis, minimum flow requirements at Vernalis, New Melones release required to meet the minimum flow requirement at Vernalis, flow required to meet the San Joaquin quality standard.

Applications: The model was developed by DWR to model the Stanislaus River system, and provides input to the model DWRSIM. Different versions of STANSIM have been used to determine the availability of water for anadromous fish flow releases potentially required by the CVPIA, and to help determine whether there was excess water available from diversions to South San Joaquin Irrigation and Oakdale Irrigation Districts.

CALFED Potential: This model has limited CALFED potential because of its limited scope. It only models the operations of the Stanislaus River and its impacts at Vernalis.

Documentation: As part of the model code, and a short introduction: STANSIM Model, version Smelt-242-F, California Department of Water Resources, 1994.

Availability: FORTRAN model. Bill Smith, California Department of Water Resources, (916)653-6079, with prior permission from the Chief of the Division of Planning.

Name and Resource Category: DWR Consumptive Use/Depletion Model

Purpose: The Depletion Model was developed to estimate the total consumptive use of water in the Sacramento and San Joaquin River basins. The model accounts for diversions, consumptive use, and return flows, and therefore is a useful tool in estimating water use and providing hydrologic boundary conditions for other models.

Approach: The model is an arithmetic accounting model that tracks diversions and return flows based on depletion study areas (DSA). DSAs are hydrologic units defined by DWR to reflect drainage patterns.

Inputs: The model inputs include land use, crop type, water imports and export, precipitation, and water demands.

Methods: The depletion model is a mass balance model that performs calculations based on the DSAs. The inputs and outputs are aggregated based on the DSA. The model includes the concept of theoretical storage to balance water supplies and demands.

Results: The model provides output such as outflow, total water supply, and total consumptive use within the DSA. The source of water, surface water or theoretical storage, is provided in the output.

Applications: The model is used to estimate consumptive use and total water use in the model boundaries. This model has been used to provide boundary conditions for DWRSIM and PROSIM model runs.

CALFED Potential: This model can be used in the CALFED process to assess the effects of land water use changes.

Documentation: There is documentation for the model, but it water prepared in the 1970's.

Availability: The model is available from DWR.

Tool & Category: **HEC-RAS; River Hydraulics**

Purpose: Compute steady-state water surface elevation profiles in natural and constructed channels for flow through bridges, culverts, weirs, and other structures.

Approach: Standard step method assuming one-dimensional, gradually varied, steady flow. Flow may be sub- or supercritical.

Inputs: Cross-sections of channel, discharge at each cross-section, reach lengths, roughness, expansion and contraction loss coefficients, and initial water surface elevation.

Methods: The program calculates energy-loss from boundary resistance (friction) and eddy loss (expansion or contraction of flow); kinetic energy coefficient is the weighted sum of kinetic energies in the main channel and overbank areas; solutions can be obtained using either momentum or energy equations.

Results: Water surface elevation, discharge, velocity among other variables.

Applications: Many river applications, not an estuary model.

CALFED Potential: Low unless applications to Sacramento, San Joaquin and other rivers are available; requires numerous cross-sections, roughness coefficients to provide reliable results.

Documentation: HEC-RAS users manual.

Availablility: Directly available from HEC to U.S. government agencies, others can obtain a copy from vendors. Hydrologic Engineering Center, 609 2nd St., Davis, CA 95616.

Contact: Gary Brunner, HEC(916)756-1104

Tool & Category: FLDWAV (replaces DWOPER, DAMBRK, and NETWORK); River Hydraulics.

Purpose: Simulates unsteady flow for a dendritic channel system to analyze flooding, hydropower operations, stormwater, and other unsteady flow.

Approach: One-dimensional, implicit finite difference solution of dynamic wave equations.

Inputs: Upstream and downstream boundaries (hydrographs of discharge or water surface elevation), internal boundaries (structures controlling water surface profile such as bridges, rapids, weirs, etc.).

Methods: Solves St. Venant equations in expanded form to include lateral inflows and outflows, nonuniform velocity distribution across flow section, expansion and contraction losses, off-channel storage, representations of flow paths for main channel and floodplain, surface wind shear effects, and viscous effects of debris flows; forecast flood flows, analyze dam breaches, floodplain mapping, design of levees and off-channel storage, analyze combined free-surface and pressure flow, calibrate Manning's roughness parameters.

Results: Discharge or water surface elevation

Applications: Relatively new model, application to the Delta has not been documented

CALFED Potential: Low, has not been applied to Delta.

Documentation: Fread, D. and J. Lewis, 1988. FLDWAV: A generalized flood routing model, Proceedings of National Conference on Hydraulic Engineering, ASCE.

Availability: Publicly available from the National Weather Service, Hydrologic Research Laboratory, 1325 East-West Highway, Silver Springs, MD 20910

Contact:

Tool & Category: DWR/RMA(-2, -4,-10); River Hydraulics.

Purpose: Simulate water surface elevation and velocity patterns at fine resolution.

Approach: Finite element, implicit solution of dynamic wave equations; original version is 1-D; -2 is 2-D, depth averaged; -4 is contaminate transport; -10 is 3-D version

Inputs: Channel geometry (bathymetery), magnitude and distribution of diversion and drainage return flows, tidal conditions, inflow hydrographs.

Methods: User defines the grid elements representing the river of concern; boundary conditions are specified; model solves the finite difference equations approximating Saint Venant (unsteady flow) equations.

Results: Velocity, water surface elevation.

Applications: DWR applied 1-D version to Delta in 1989; boundaries for Delta are Sacramento, Vernalis, and Martinez; includes operation of SWP Clifton Court Forebay, existing and planned hydraulic structures (e.g. Delta Cross Channel, Suisun Marsh Salinity Control Gates), and recent descriptions of diversion and return flows; DWR/RMA has been replaced by DWR/DSM; RMA-2 is still used; DWR applications include San Francisco Bay, Sacramento River (Freeport to Snodgrass Slough; COE has also used this model; programs used in conjunction with RMA-2 include SED2D for sediment transport and SMS (previously Fast TABs) for I/O processing; UCD is applying the model to salmon in an ecological analysis using a particle tracking module.

CALFED Potential: Useful for analyzing river velocity/discharge at specific sites; Delta-wide version has been replaced by DSM.

Documentation: Briefly documented in DWR, 1990. Draft EIR/EIS North Delta Program. RMA will provide extensive documentation.

Availability: Original RMA model is public domain, marketed by vendors; RMA-2 and -10 is commercially available from RMA and other vendors (BYU, BOSS).

Contact: Shawn Mayr, DWR; Ian King, RMA; Joe Letter, COE WES; Jamie Anderson, UCD.

Tool: Hydrologic Simulation Program/Fortran (HSPF)

Category: Watershed Hydrology and Water Budgets

Purpose: Simulate watershed hydrology and water quality for point and nonpoint source pollutants.

Approach: Stanford Watershed Model.

Inputs: Rainfall, temperature, solar radiation, soils, topography, land cover.

Methods: Incorporates watershed-scale Agricultural Runoff Model (ARM) and Non-Point Source (NPS) models.

Results: Discharge and pollutant concentrations time series.

Applications: May be used for streams or other well mixed systems only.

CALFED Potential: Could be applied to Central Valley streams.

Documentation: Application Guide for Hydrological Simulation Program--FORTRAN, EPA/600/3-84/065, NTIS: PB84-215-763. HSPF: User's Manual for Release 8.0, EPA/600/3-84/066, NTIS: PB84-224-385.

Availability: Public domain. Available from Center for Exposure Assessment Modeling, Environmental Research Laboratory, USEPA, Athens, GA 30613-0801. Catherine E. Green, (706) 546-3210, 546-3340 (fax).

Tool & Category:	PRMS (Precipitation Runoff Modeling System) Surface Water
Purpose:	Model used to simulate watershed snow and precipitation runoff.
Approach:	Two-dimensional single layer, dynamic, numerical mass-balance model.
Inputs:	Daily precipitation, maximum and minimum temperatures, and solar radiation. User defined Hydrologic Response Units (HRUs) for model grid (i.e., areas with hydrologic similarity). Properties of HRUs defined for layer thickness, slope and aspect, elevation, soil type and permeability, vegetation characteristics (percentage cover, precipitation retention, evapotranspiration).
Methods:	Model calculates daily snow pack, precipitation, and snow melt and assumes all water in excess of available storage and losses is input to adjacent HRUs with lower elevation. Model utilizes hierarchial approach to satisfy ET demand from vegetation to surface sources to soil moisture. All available water in HRU adjacent to a surface channel is added to stream flow budget within same time step. Darcy groundwater flow equation used to calculate soil moisture to adjacent HRUs. Total stream flow computed with simple mass balance of channel nodes. Model performs calculations on daily time step. Model does not account for any channel routing or in-stream storage. Fortran code on either PC-DOS or UNIX platforms.
Results:	Daily output for snow pack coverage, water storage by source, and total stream flow.
Applications:	Primarily used for detailed water supply forecasting of high elevation mountainous regions for complex snow and precipitation analyses. Has been applied to North Fork American River, East Fork Carson River, and currently for Merced.
CALFED Potential:	Relatively low applicability for wide scale planning or alternatives analysis.
Documentation:	USGS - public domain.
Availability:	George Leavesley, USGS - Denver, (303)-236-5027

Tool & Category: **CUDACOMP** **Reservoir Operation/Surface Water**

Purpose: Automate hydrology development for use with DWRSIM planning studies. Possibly to eventually be linked to DWRSIM.

Approach: Combination of three DWR models: Consumptive Use (CU), Depletion Analysis (DA), and the COMP model.

Results: The Consumptive Use model provides estimated historical water use and projected water requirements by month for use as input to the Depletion Analysis program. It maintains a soil water budget and calculates the allocation of water use by plants from rainfall, stored soil moisture, and irrigation. The Depletion Analysis model determines the effects of future water demands and future storage and diversion regulation on the historical flows of the river systems tributary to the Delta. The COMP model is a general purpose FORTRAN program designed to carry out mathematical operations on tables in spreadsheet format. The final result is a new main.dat file for DWRSIM.

Applications: Using this model, one can do different kinds of hydrology development: extending the simulation period, modifying land use projections, or improving simulation of the physical system.

CALFED Potential: None currently. In the future, if/when CUDACOMP is perfected, and it is linked to DWRSIM, it will provide hydrology changes directly to DWRSIM.

Availability: Not available. An executive decision was made at DWR to deny access to this model because Tariq Kadir is the only person familiar with the model, and it has only been tested at the 1995 level for the years 1922-1992. Reliable output is available by running the three models separately, as is currently done at DWR. Tariq Kadir, Department of Water Resources, (916)653-3513.

Name and Resource Category. Regional Aquifer-System Analysis of the Central Valley, RASA-CV, for groundwater

Purpose. The RASA Program was implemented by the USGS following a congressional mandate to develop quantitative appraisals of the major groundwater systems of the United States This model was developed as an important part of that effort.

Approach. A three-dimensional finite-difference groundwater flow program was used to simulate groundwater flow and land subsidence in the Central Valley aquifer system.

Inputs. Input data includes pre-computed net recharge-discharge values, and aquifer properties.

Methods. The model simulates three-dimensional groundwater flow in the aquifer system.

Results. Model output includes groundwater budgets, land subsidence conditions, and groundwater heads.

Applications. The RASA-CV was calibrated but has not been appied for future water management and planning. Aquifer parameters from this model were incorporated into the CVGSM model.

CALFED Potential. This model could simulate groundwater conditions in the Central Valley under CALFED alternative definitions. However, the net recharge-discharge amounts are an input to the model and would require considerable effort to develop. Furthermore, interaction between groundwater and surface water is not simulated.

Documentation. The model is well documented.

Availability. The model is in the public domain and is available from the USGS.

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Name and Resource Category. Central Valley Groundwater Surface water Model, CVGSM, for groundwater (with surface water interaction)

Purpose. The model was written to simulate surface and groundwater flow in the central valley. This model was developed for a team of federal, state and local water agencies including Reclamation, DWR, SWRCB, and Contra Costa Water District.

Approach. The CVGSM is a finite-element groundwater flow model with surface water stream routing. The model employes land and water use estimates, topography, precipitation, stream geometry, and geologic parameters to simulate the Central Valley water system. The model in subdivided into approximately 1400 elements with an average size of 14 square miles representing areas of relatively uniform conditions.

Inputs. Input data includes stream inflow to model boundaries, precipitation, aquifer properties, initial groundwater head and soil moisture, and landuse.

Methods. The model uses the consumptive use method to compute water demand. Available water diversions and deliveries are simulated. The model routes sreamflow, return flow, groundwater percolation, and groundwater pumping.

Results. Model output includes water budgets for land & water use, groundwater, stream flow and soil moisture. Groundwater heads can be summarized using hydrographs for specific areas, and contours for specific time periods.

Applications. CVGSM is IGSM applied to the Central Valley. It simulates all of the major rivers and diversions using inflow, district-based land use, and groundwater parameters. It has been used for the groundwater analysis in the CVPIA PEIS.

CALFED Potential. This model would be appropriate to analyze potential impacts of CALFED alternatives on groundwater conditions in the Central Valley.

Documentation. The model is well documented, with a Dec 1993 updated documentation.

Availability. The model is in the public domain and is available from the Reclamation, Mid-Pacific Region. A recalibration effort is currently underway, but the model is ready to use with the previous calibration.

Tool & Category: **SANTUCM (San Joaquin-Tulare Conjunctive Use Model) Surface Water/Groundwater**

Purpose: Developed to simulate surface water operations, groundwater flow, and the interaction between surface water flow and regional groundwater within the San Joaquin Basin from Millerton Lake to the Delta, and the Tulare Basins from south of Mendota to Bakersfield. A salinity model was developed to perform simple mass balances of salt load.

Approach: Comprises three separate models: a surface water model, a groundwater model, and a salinity model. The surface water model performs mass balances of flow along each stream reach every month based on surface water nodes. The groundwater model uses finite element analysis to calculate a mass balance numerically, based on groundwater grid nodes. The salinity model was not satisfactorily completed. A linkage subroutine performs iterations of the models.

Inputs: The major surface water model inputs include inflows, irrigation efficiencies, reservoir storage limits, and hydropower parameters. The major groundwater model inputs include stream node locations, diversion point locations, and groundwater pumping data.

Methods: The model can be run three different ways: surface water model, groundwater model, and linked surface water and groundwater models.

Results: The major surface water model outputs include flow values in streams and canals, water deliveries at various demand points, pumping rates, and recharge factors. The major groundwater model outputs include groundwater levels and values of soil-moisture accounting variables such as soil moisture accretion and evapotranspiration from shallow water table.

Applications: The model is designed as a planning tool to help evaluate the impacts of alternative instream flow criteria, changes in operations, increased conjunctive use of groundwater resources, power generation and new physical facilities within the San Joaquin Basin.

CALFED Potential: None. SANTUCM has several problems, including: there is occasionally poor agreement between surface water model-derived and groundwater model-derived estimates of stream gains or losses; SANTUCM cannot estimate subsurface drainage and therefore cannot distinguish between surface and subsurface return flows to the river; the salinity model has not been satisfactorily completed.

Documentation: *Evaluation and Suggestions for Further Development of the San Joaquin-Tulare Conjunctive Use Model (SANTUCM)*. Prepared for Division of Planning and Technical Services, United States Bureau of Reclamation, Sacramento, California. March 1992. *Computer-Based Decision Support Models for Evaluation of Actions Affecting Flow and Water Quality in the San Joaquin Basin*, January 1993. Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Availability: Nigel Quinn, Bureau of Reclamation, (916)979-2325.

Name and Resource Category. Hydraulic Economic Model (HEM) for groundwater, surface water, agricultural production, and agricultural economics.

Purpose. The HEM was developed by RMA for DWR to simulate agricultural water demand and water use in the San Joaquin Valley.

Approach. This model is composed of four separate models which can be used individually or in combination. San Joaquin valley groundwater conditions are simulated using the surface water model (SWAM) and the finite element groundwater model (GWM).

Inputs. Input data includes stream inflow to model boundaries, precipitation, aquifer properties, initial groundwater head and soil moisture, and landuse.

Methods. The SWAM represents the valleys streams and canals constituting the surface water system and is designed to compute surface water budgets, as well as pumpage and recharge to the groundwater aquifer for input to the GWM. The GWM is a two-layer finite-element groundwater flow model consisting of one unconfined layer and one confined layer which are separated by the E-clay.

Results. Model output includes surface water and groundwater budgets, land subsidence conditions, and groundwater heads.

Applications. The groundwater module of HEM has been modified and used in several site specific applications including the Kern Basin (KBGWM).

CALFED Potential. This model could simulate groundwater conditions in the San Joaquin portion of the Central Valley under CALFED alternative definitions. However, the model does not include the Sacramento Valley portion and therefore would be of limited use.

Documentation. The model documentation is available from DWR, San Jaoquin District in Fresno.

Availability. The model is in the public domain and is available from the DWR.

Name and Resource Category. Western San Joaquin Valley groundwater model, for groundwater

Purpose. This model was developed by the USGS to simulate groundwater flow in the western San Joaquin Valley in the Westlands Water District area.

Approach. The MODFLOW code was applied to simulate groundwater flow in this area. MODFLOW is a three-dimensional finite-difference groundwater flow program.

Inputs. Data input includes pre-computed net recharge-discharge values.

Methods. The model simulates three-dimensional groundwater flow in the aquifer system.

Results. Model output includes groundwater budgets, and groundwater heads.

Applications. This model was used to simulate the Westlands Water District groundwater conveyance program using the California Aqueduct.

CALFED Potential. This model is a local application, and is site-specific for the modeled area.

Documentation. The model is documented.

Availability. The model is in the public domain and is available from the USGS.

Tool & Category: **Panoche Ground Water Flow Model** **Ground Water**

Purpose: Ground water flow model of part of the western San Joaquin Valley using the USGS modular the-dimensional finite-difference ground-water flow model (MODFLOW).

Approach: Steady-state, finite-difference approximation.

Inputs: Prescribed inputs include: recharge to the saturated zone, parameters describing bare-soil evaporation and drain conductances, equivalent horizontal and vertical hydraulic conductivity, hydraulic heads along the lower model boundary, and fluxes along eastern and southern model boundaries.

Methods: A steady-state, three-dimensional, numerical ground-water flow model is used to reproduce average hydrologic conditions during 1987-91. The resulting water budget was used to quantify the recharge and ground-water components contributing to annual on-farm drainflow.

Results: Distribution of hydraulic heads and volumetric fluxes.

Applications: Prepared by the U.S. Geological Survey in cooperation with the Panoche Water District and Department of Water Resources to calculate a ground-water budget and evaluate the contribution of regional ground-water flow to on-farm drainflows in the Panoche Water District.

CALFED Potential: This is a MODFLOW based model of a limited area developed for a specific situation. Therefore, it has limited CALFED potential.

Documentation: Source Code: Mc Donald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 6, Chap. A1, 576 p.
Fio, John L., 1994, Calculation of a water budget and delineation of contributing sources to drainflows in the western San Joaquin Valley, California: U.S. Geological Survey Open-File Report 94-45, 39 p.
Fio, John L., and David A. Leighton, 1994, Effects of ground-water chemistry and flow on quality of drainflow in the western San Joaquin Valley, California: U.S. Geological Survey Open-File Report 94-72, 28 p.

Availability: Free access, U.S. Geological Survey, Water Resources Division, California District, 2800 Cottage Way, Room W-2235, Sacramento, CA 95825. Phone: (916)979-2668. Contact: John Fio, Hydrologic Consultants, Inc., 756-0925.

Tool & Category: **Kesterson Reservoir Groundwater Model** **Ground Water**

Purpose: Simulate groundwater flow for a 124 square-mile area in the vicinity of Kesterson Reservoir in the San Joaquin Valley, California.

Approach: Based on the U.S. Geological Survey modular three-dimensional finite-difference model.

Inputs: Inputs to the model include: finite-difference grid of the study area, estimated horizontal and vertical hydraulic conductivities, estimated specific yield, boundary conditions, and measured hydraulic heads.

Methods: Available data was used to calculate a probable range of groundwater flow rates and directions of groundwater flow. The groundwater flow equation that was solved is for three-dimensional groundwater flow of a homogeneous compressible fluid through a nonhomogeneous anisotropic aquifer, using the slice-successive-over-relaxation and pre-conditioned conjugate gradient methods. The model includes head dependent groundwater sources and sinks.

Results: The model calculates groundwater elevation. The horizontal and vertical directions of groundwater movement are then estimated using groundwater elevation gradients. First order approximations of groundwater traveltimes and travel distances can also be made from volumetric fluxes using the groundwater flow model.

Applications: The model was used to simulated hydraulic heads and groundwater flow rates for (1) groundwater flow conditions typical of winter-spring months during which groundwater levels are highest, (2) a 3-year period during which agricultural drainage water flowed into Kesterson Reservoir, and (3) average groundwater conditions measured during summer-fall months during which groundwater levels generally are at their lowest level.

CALFED Potential: Limited. This is a MODFLOW based model of a specific region that was not calibrated or tested by comprehensive sensitivity analyses. The CALFED program would benefit more from a more extensive and trustworthy model.

Documentation: R.J. Mandle and A.L. Kontis, 1986. *Directions and Rates of Ground-Water Movement in the Vicinity of Kesterson Reservoir, San Joaquin Valley, California.* U.S. Geological Survey Water-Resources Investigations Report 86-4196.

Availability: The availability of this model depends on the U.S. Geological Survey's ability to locate it. Because the authors cannot be located, it may be impossible to find. Contact the local office of the U.S. Geological Survey for more information concerning their whereabouts.

Tool & Category: **MODFLOW** **Ground Water**

Purpose: Determines groundwater elevations, drawdown, and volumetric budget, using inputs describing the hydrological environment and the calculation method.

Approach: Three-dimensional modular finite-difference model written in FORTRAN 77. Because it is a modular model, it can be customized to fit the hydrologic system being modeled.

Inputs: Depends on which modules are utilized. Some inputs that are required to run the program with any module are: three dimensional configuration of area to be modeled, simulation period, stress period length, aquifer parameters, and initial groundwater elevations. Generally, the inputs are some type of hydrologic data.

Methods: Modules are included in the model being developed as they are needed. Modules that can be used, depending on the system being modeled, include: river package, recharge package, well package, drain package, evapotranspiration package, general-head boundary package, streamflow-routing package, strongly implicit procedure package, preconditioned conjugate gradient 2 package, and slice-successive overrelaxation package.

Results: Like the input, this also depends on which modules are utilized, and how often output data is saved to the output file depends on the preference of the model user. Groundwater elevations, drawdown, and volumetric budget are calculated accorded to the length of the stress period chosen. There will also be output corresponding to the inputs, such as stream flow into an aquifer.

Applications: MODFLOW can be used to calculate groundwater elevations for a system with known parameters. The model can estimate changes in drawdown/groundwater elevations due to changes in the management of a hydrologic system.

CALFED Potential: Could be used to determine the impacts on groundwater elevations of different surface water, groundwater, and land management options. Produces a volumetric budget, drawdown, and groundwater elevations at an interval specified by the user, so one could identify incremental changes in the groundwater system if suitable hydrologic data is available.

Documentation: Techniques of Water-Resources Investigations of the United States Geological Survey; Chapter A1; A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model by Michael G. McDonald and Arlen W. Harbaugh (1988). As this is one of the most commonly used groundwater models, it is the basis of many studies.

Availability: FORTRAN model. At cost from Chief, Office of Ground Water, MS 411, National Center, U.S. Geological Survey, Reston, Virginia 22092

Name and Resource Category. Integrated Groundwater Surface water Model, IGSM, for groundwater (with surface water interaction)

Purpose. The model was written as a generic code to simulate surface and groundwater flow in any groundwater region. This model has been developed and refined in conjunction with numerous regional applications in California.

Approach. The IGSM is a finite-element groundwater flow model with surface water stream routing. The model employes land and water use estimates, topography, precipitation, stream geometry, and geologic parameters to simulate an aquifer system. Elemental discretization may be set to any appropriate size and may include three and four sided elements.

Inputs. Data input includes stream inflow to model boundaries, precipitation, aquifer properties, initial groundwater head and soil moisture, and landuse.

Methods. The model uses the consumptive use method to compute water demand. Available water diversions and deliveries are simulated. The model routes sreamflow, return flow, groundwater percolation, and groundwater pumping.

Results. Model output includes water budgets for land & water use, groundwater, stream flow and soil moisture. Groundwater heads can be summarized using hydrographs for specific areas, and contours for specific time periods.

Applications. The IGSM applications appropriate for the CALFED analysis include the Central Valley (CVGSM), the Salinas Valley (SVGSM), the American River Service Area (ARGSM), and the Friant-Kern Service Area (FSAGSM).

CALFED Potential. Other than the Central Valley application, specific applications of the model would most likely be too site-specific for a CALFED programmatic analysis of groundwater impacts.

Documentation. The model code and the specific applications are well documented, and are available from the responsible agencies.

Availability. The model is in the public domain and is available from Reclamation, Mid-Pacific Region. Specific applications are available from the responsible agencies.

D-003393

Tool & Category: **Transient three-dimensional ground-water flow model of the central part of western San Joaquin Valley** **Ground Water**

Purpose: To aid in assessing alternatives to agricultural drains for managing shallow, saline ground water.

Approach: Combined use of parameter estimation, water balance, steady-state and transient 3-D finite-difference models, and a suite of grossly-defined management alternatives.

Inputs: Hydraulic conductivity/transmissivity, leakance, pumpage, evapotranspiration, drainflow, recharge, specific yield, storage coefficient, system geometry.

Methods: Horizontal and vertical hydraulic conductivities for each model cell above the Corcoran Clay were estimated on the basis of textural (grain size) information and a sophisticated 2-stage calibration procedure involving both the steady-state and transient models. Recharge and pumping were estimated using a crop-based water budget approach.

Results: The output is hydraulic heads, which were compared to heads in about 500 wells in the study area during model calibration.

Applications: The model was prepared by Ken Belitz, Steve Phillips, and Jo Ann Gronberg of the USGS (Ken Belitz is now associated with Dartmouth University). Belitz and Phillips used the model to test the effects of various management strategies, including land retirement, source control, increased ground-water pumping, and combinations of these techniques. It was found that (1) land retirement will result in a water-table decline beneath the area retired, but the effect on adjacent areas will be negligible; (2) the effects of reducing recharge or increasing ground-water pumping vary with the magnitude of the change relative to average conditions and the size of the area managed; and (3) the area underlain by shallow water (within 7 ft of land surface) can be reduced to 78 square miles (from 224 squire miles in 1990), and the drain flow to 8,000 acre-feet/year (from 25,000 acre-feet/year in 1990) if recharge is reduced by 15% in areas that currently use surface and ground water, recharge is reduced by 40% in areas that only use surface water, and pumping rates are uniformly incremented by 0.5 ft/year in both areas.

CALFED Potential: This model has limited CALFED potential because of its limited scope. However, it has had some interesting and extremely relevant water management applications.

Documentation: Belitz, Kenneth, Phillips, S.P., and Gronberg, J.M., 1992, Numerical simulation of ground-water flow in the central part of the western San Joaquin Valley, California: U.S. Geological Survey Open-File Report 91-535, 71p.
Phillips, S.P., and Belitz, Kenneth, 1991, Calibration of a texture-based model of a ground-water flow system, western San Joaquin Valley, California: Ground Water, v.29, no.5, pp. 702-715.

Availability: Ken Belitz: E-mail ken_belitz@dartmouth.edu, phone (603)646-3365, or Steve Phillips: E-mail sphillip@usgs.gov, phone (916)278-3002

Tool & Category: **FLOW3D** **Ground Water**

Purpose: To simulate groundwater flow.

Approach: Finite-element three-dimensional groundwater flow model. It has special facilities for the simulation of water-table aquifers and land subsidence. It also includes a data-management system for the organization and use of detailed data for irrigated agricultural systems.

Inputs: A brief summary of inputs includes: spacial description of basin in terms of model nodes and elements, aquifer parameters, initial hydraulic heads, specified head boundary conditions, internal and boundary fluxes, stream-aquifer interactions, variable flux boundary conditions, fault boundaries, land subsidence parameters, and well construction data.

Methods: FLOW3D uses the Galerkin finite-element method in space and the finite-difference method in time. The finite-element method is applied to tetrahedral or triangular linear elements for volume or surface integrations. A fully implicit finite-difference representation is applied in time for temporal integrations. FLOW3D uses a deforming grid and an iterative procedure to simulate the hydraulic response of a three-dimensional water-table aquifer.

Results: A partial list of output data includes hydraulic heads, mass balance, change in land surface elevation, inflows and outflow at specified head boundaries, stream nodes, summaries of pumping, deliveries, groundwater recharge, and evapotranspiration for each user area.

Applications: Using FLOW3D, a groundwater model of Butte Basin was developed for the Butte Basin Water User Association by Linda Bond in 1995. The Butte model will be maintained and updated on an ongoing basis and be used to aid in the management of groundwater resources for the region. (FLOW3D, developed by Timothy J. Durbin currently of HCI, has been applied to many groundwater basins throughout the state.)

CALFED Potential: FLOW3D appears to have extensive possibilities for the CALFED program. It would be useful for modeling the impacts of new water management strategies. It has applications for irrigated agricultural systems and subsidence (which I have not seen before), in addition to modeling groundwater flow.

Documentation: *FLOW3D: A Finite-Element Program for the Simulation of Three Dimensional Aquifers* (Hydrologic Consultants, Inc., 1994) and *Development of a Ground-Water Model, Butte Basin, California* (Hydrologic Consultants, Inc., 1996)

Availability: Hydrologic Consultants, Inc. expects FLOW3D to be published by both the U.S. Geological Survey and the International Groundwater Modeling Center (IGWMC) by the end of 1996. The format for publication through the USGS has not been determined. It may be available through the INTERNET. IGWMC is located in Fort Collins, CO (phone: (303) 273-3103). Linda Bond, Hydrologic Consultants, Inc., (916) 756-0925.

Tool & Category: **eXterra (central)** **Ground Water**

Purpose: Groundwater elevation database for Contra Costa, San Joaquin, Sacramento, Solano, Yolo, Sutter, Yuba, Placer, Nevada, El Dorado, Napa, Sonoma, and Mendocino Counties. The data is collected on a semiannual basis, primarily, with some monthly readings. The database does include some old project specific data that was collected weekly. The earliest readings are from about 1920, though most begin in the 1930s and 1940s.

Approach: Stored in R:Base, but distributed in ascii delimited (6 field) format. There are district reports that contain groundwater levels and hydrographs by county.

CALFED Potential: This data can be used as input to any models or studies requiring groundwater elevations.

Availability: Eric Senter, Department of Water Resources, (916)227-7571. Soon to be on the Internet.

Tool & Category: **eXterra (north)** **Ground Water**

Purpose: Groundwater elevation database for Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Shasta, Lassen, Tehama, Plumas, Butte, Glenn, Colusa, Lake, Mendocino, and Sierra Counties. The data is collected on a semiannual basis, primarily, with some quarterly and monthly readings. The earliest readings are from about 1920, though most begin later.

Approach: Stored in R:Base, but distributed in ascii delimited format. There are district reports available that contain groundwater levels and hydrographs by county.

CALFED Potential: This data can be used as input to any models or studies requiring groundwater elevations.

Availability: Pat Huckabay, Department of Water Resources, (916)529-7314. Soon to be on the Internet.

Tool & Category: Fischer Delta Model; Hydrodynamics, Water Quality.

Purpose: Simulate hydrodynamics and salinity in the Sacramento-San Joaquin Delta.

Approach: One-dimensional, finite difference, method of characteristics solution of dynamic wave equation; Lagrangian salinity transport model.

Inputs: Delta geometry, stream discharges, agricultural drainage, tide at Crockett.

Methods: Model comprises five subroutines (GEOM, DELFLO, HYDROL, ENDSAL, and DELSAL). GEOM provides dimensions of Delta channels. DELFLO uses a finite difference scheme and the method of characteristics to solve one-dimensional transport equations (continuity and momentum). DELSAL calculates salinity with a Lagrangian approach -discrete volume elements move along the channel subject to longitudinal dispersion, inflow, and outflow.

Results: DELFLO provides surface water elevation, DELSAL provides salinity concentrations.

Applications: Developed for the Delta.

CALFED Potential: Has been incorporated into many models (e.g., DWR/DSM), but license is required for use.

Documentation: Fischer, 1982. DELFLO and DELSAL flow and transport models for the Sacramento-San Joaquin Delta in Bureau of Reclamation, 1987, Kellogg unit reformulation study planning report/draft environmental statement water quality and hydrology appendix.

Availability: Must be licensed

Contact: Greg Gartrell, CCWD; Henry Wong, Bureau

Tool & Category: Contra Costa Water District Salinity Model; Hydrodynamics, Water Quality

Purpose: Model salinity, in particular at CCWD intakes.

Approach: Fischer model.

Inputs: Same as Fischer model, improved geometry

Methods: Method of characteristics solution to hydrodynamics and Lagrangian transport for salinity, new routine for calculations at confluences to eliminate numerical dispersion which caused a flow loss 300 cfs); rectangular channels.

Results: Salinity.

Applications: Bay-Delta from Carquinez Straits upstream to Sacramento and Vernalis.

CALFED Potential:

Documentation: Los Vaqueros Project Description

Availability: Not public

Tool & Category: **TRIM 2D and 3D; Hydrodynamics, Water Quality.**

Purpose: Simulate salinity in Bay estuary (San Francisco, San Pablo, and Suisun Bays).

Approach: Two- and three-dimensional, semi-implicit, finite difference solution of dynamic wave equations.

Inputs: Tide at Golden Gate, Discharge at Rio Vista, mesh representing the estuary.

Methods: TRIM 2D calculates vertically averaged hydrodynamics and salinity transport

Results: Vertically-averaged salinity from TRIM 2D

Applications: USGS has applied TRIM 2D throughout the entire estuary downstream of Chips Island, for example, a 50 m mesh has been developed to represent Suisun Bay; a 250 m grid for TRIM 3D is being developed for the whole Estuary.

CALFED Potential: USGS is going to be using a new 3-D model.

Documentation: Cheng et al., 1993. Estuarine, Coastal , and Shelf Science 36: 235-280 (application to SFB); Journal of Computational Physics 80: 56-74 (numerical methods).

Availability: Public

Tool & Category: **Uncles/Peterson Model; Hydrodynamics, Water Quality**

Purpose: Simulate tidally-averaged current and salinities at a daily scale for predictive applications.

Approach: Intertidal estuarine model.

Inputs: Bathymetry; precipitation; evaporation; salinity at the mouth of the estuary; freshwater inflow; and tidal state.

Methods: UP uses look-up table (generated by TRIM) of maximum current velocity, tidal energy dissipation, and bed stress as a function of tidal state (from weak neap to strong spring); 50 two-layered segments provide a coarse resolution of the Bay-Delta; at each time step, UP calculates across-segment flows and volumetric mixing

Results: Salinity for each segment

Applications: Used to simulate salinity in Bay-Delta for 1967-81.

CALFED Potential: For predicting major multiyear effects on the Bay-Delta.

Documentation: Knowles et al., 1995. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter, Autumn 1995: 8-10.

Availability: Likely public (USGS involved in development).

Tool & Category: DWR/DSM2; Hydrodynamics, Water Quality.

Purpose: Simulate Delta hydrodynamics and water quality parameters

Approach: Implicit, four-point finite difference solution of dynamic wave equations; Lagrangian transport for water quality; allows irregular cross-sections for channels and flow in response to density gradients.

Inputs: HYDRO boundary conditions are tides at Benicia, flow at Sacramento and Vernalis, +smaller inflows; HYDRO includes incremental operation of structures (Cross-channel near Walnut Grove, Suisun Marsh Salinity Control Gate, Clifton Court Forebay tidal gates, other planned South Delta gates), agricultural diversions and returns; other inputs include channel geometry; user can specify date, time and model will access DWR data bases for boundary conditions - tides, discharge, diversion, return, etc.); QUAL requires discharge, flow area, top width of channel, water quality for inflow; PTM requires flow velocity and channel geometry (from HYDRO).

Methods: Integrates three components -HYDRO, -QUAL, and -PTM; HYDRO solves dynamic wave equations for variable tides, river flows using an implicit finite-difference scheme and irregular cross-section geometry for channels, HYDRO is based on FOURPT (USGS), in comparison to DSM, DSM2-HYDRO provides stable solutions for large time-steps because of the implicit scheme, improved representation of channel shape (irregular geometry) using updated bathymetry; QUAL is based on the Branched Lagrangian Transport Model (USGS) that simulates transport and kinetic reactions of water quality parameters; PTM provides 3-D dispersion of neutrally-buoyant particles using 1-D velocity vector from HYDRO and simulated transverse and vertical velocity profiles

Results: Discharge, stage, velocity, temperature, BOD, DO, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic phosphate, dissolved inorganic phosphate, phytoplankton, and arbitrary constituent.

Applications: Specifically developed for the Delta; network may extend north to Shasta and west to Golden Gate; irregular geometry will allow analysis, for example, of dredging. DSM2-QUAL DO simulation has been calibrated with DO profile from 9/20/88 and verified with DO profile from 10/12/88 for the San Joaquin River near Stockton; MWD will be using this model as well.

CALFED Potential: This model is being developed by DWR for the Interagency Ecological Program.

Documentation: DWR, 1994. Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 15th annual progress report to the SWRCB.

Availability: Will be public.

Contact: Paviz Nader, DWR; Lew Delong, USGS (Mississippi); Chuching Wang, MWD.

Tool & Category: **Suisun Marsh DWR/DSM; Hydrodynamics, Water Quality.**

Purpose: Simulate salinity changes in Suisun Marsh

Approach: One-dimensional, explicit, finite difference, method of characteristics solution of dynamic wave equations; Lagrangian salinity transport model; rectangular channels.

Inputs: See DWR/DSM; non-repeating tides at Golden Gate.

Methods: See DWR/DSM; non-repeating tides; includes major flow control facilities (SMSCG) and wetland annual diversion and drainage operations; run at 1 minute time-step for hydrodynamics and 5 minute time-step for salinity transport.

Results: Specific conductance at various stations around Suisun Bay.

Applications: Calibrated for WY 1990, verified for WY 1987-94.

CALFED Potential: For examination of Suisun Bay.

Documentation: See DWR/DSM.

Availability: Licence needed.

" G Model "

Tool & Category: **CCWD Salinity Outflow Model**

Purpose: Predict salinity given outflows or calculate flows required to attain a given salinity level.

Approach: One-dimensional, uasi-empirical, spreadsheet model solving state-state dispersion equation at each time step.

Inputs: Daily flows

Methods: Longitudinal dispersion for estuary (1-D) accounting for advection; steady-state solution of "G function" (a function of time) to get ordinary differential equation for each time step.

Results: Salinity or inflows to Delta

Applications: Used with EPA, SWRCB to evaluate X2; predict salinity knowing flows; extends predictions to Rock Slough (interior Delta Standards).

CALFED Potential: Solves inverse problem (what flows are needed to attain specified salinity levels)

Documentation: SWRCB Water Quality Plan - Environment Report

Availability: Publically available

Tool & Category:	WADE (Westside Agricultural Drainage Economics Model); Agricultural Water Quality
Purpose:	Estimates agricultural production, water supply, and drainage return flow quantity and quality in response to different economic and regulatory drainage management strategies for the San Joaquin River valley.
Approach:	Integration of deterministic mass-balance hydrosalinity and economic optimization sub-models.
Inputs:	User defined cell grid (size 4,000 to 40,000 acres). Inputs for each cell include land use, crops, commodity prices, costs of production, hydrologic variables (ET, rain), groundwater levels, groundwater pumping, presence of tile drainage, irrigation method, and water quality.
Methods:	General Algebraic Modeling System (GAMS) based code for UNIX Workstations. Linked agricultural production, hydrology, and salinity models perform optimization routines for two annual time steps representative of summer and winter conditions. During each iteration, the agricultural production model estimates the land use activity and factors of water application; the hydrology model determines groundwater flow, irrigation recharge, and drainage; and the salinity model estimates salt transport. Salt balance in the root zone, in turn, affects crop yields and decisions made by agricultural production model in the following time step.
Results:	Annual values for land use, farm income, depth to water table, drained area, pumping, drainage quantity, drainage quality, and root zone salinity.
Applications:	Used as a comparitive planning tool to evaluate alternative land use strategies in westside San Joaquin valley. Limitations include no channel surface hydrology. Model was difficult to calibrate due to lack of data in applicable format.
CALFED Potential:	The concept of linked hydrologic, water quality, and agricultural land use models should be pursued to provide optimization of hydrology, water quality, agricultural, and economic effects under alternative CALFED actions. The development of an appropriate analytical approach could include a single model such as WADE or linkage of existing models into a decision support system. Approach could provide focus for refined inputs of primary assessment models.
Documentation:	Available.
Availability:	USBR public domain.

Tool & Category:	HYSAM (Hydrosalinity Model); Agricultural Water Quality
Purpose:	Water quality model that simulates subsurface hydrology, root zone salinity, and influence of gypsum chemistry on water quality.
Approach:	Two-dimensional, steady state, mass-balance soil hydrology and salt balance model; and dynamic finite element version.
Inputs:	Soil profile physical and chemical characteristics, hydrologic inputs, and water quality parameters.
Methods:	HYSAM and C-HYSAM are mass balance models developed for steady state and transient simulations respectively. Geometry of modeled area is user defined and C-HYSAM uses any specified time step. D-HYSAM is a dynamic numerical finite element model. Model does not explicitly compute hydrologic balance and consumptive use according to crop type.
Results:	Principal output is salinity of the crop root zone including annual summaries.
Applications:	Earliest versions used for hydrologic and salinity mass balance simulations for irrigation projects in Glenn-Colusa and Panoche areas. Dynamic version developed to perform transient simulations of water and salt balance and drainage recycling effects in the San Luis area. D-HYSAM currently being used to simulate effects of salt tolerant trees and halophytes on selenium and salt transport at a San Joaquin Valley test field (Karajeh pers. comm.).
CALFED Potential:	Can provide refined analyses of drainage quality for primary of secondary assessment models. Or can be used to calculate effects on root zone salinity from alternative water management policies.
Documentation:	HYSAM and C-HYSAM documentation available. D-HYSAM documentation in progress with completion expected in 1996.
Availability:	HYSAM and C-HYSAM are available. Fawsi Karajeh, DWR, (916) 327-1828

Tool & Category:	Rice Herbicide Reduction Monitoring Program; Agricultural Water Quality
Purpose:	Historical water quality monitoring that was conducted from mid 1980s to 1993 to study the effects of alternative management and regulatory control of pesticide applications in rice fields.
Approach:	Water quality monitoring and data collection program.
Inputs:	The program was funded as part of the RWQCB (Central Valley).
Methods:	Bi-weekly / monthly / quarterly samples from ## major drainage canals and ## main river segment locations in upper Sacramento River basin.
Results:	Parameters available include pesticides (molinate, thiobencarb), conventionals (EC, pH, DO, temperature).
Applications:	Monitoring led to Department of Pesticide Regulation permit system and required management practices for rice growers. Dramatic decrease in pesticide levels documented following application and management restrictions.
CALFED Potential:	Large data base of water quality information directly applicable to rice growing operations.
Documentation:	
Availability:	Rudy Schnagl, SWRCB, Sacramento, CA (916) 255-3101

Tool & Category:	IRDROP (Irrigation and Drainage Operations Model); Agricultural Water Quality
Purpose:	Model that simulates irrigation decisions to optimize costs of groundwater pumping, direct discharge, and temporary storage in order to meet specified water quality objectives of San Joaquin River.
Approach:	Finite element mass-balance hydrosalinity model.
Inputs:	Inputs for each cell include land use, crops, hydrologic variables (ET, rain), groundwater levels, groundwater pumping, drainage, and water quality. Land units classified according to percentage land tile drained, without tile drainage, and without tile draingage and having shallow water tables.
Methods	Model compares monthly drainage and selenium and boron transport with river objectives. In turn, hydrology component optimizes direct discharge, drainage recycling, and temporary storage to minimize costs. Water application is determined from root zone salt balance. Code is refined from WADE model to simulate monthly time steps. Drainage water quality is determined by assuming fixed ratio of losses to shallow ground water, deep percolation, and deep groundwater.
Results:	Monthly flow volumes for drainage, direct discharge, temporary storage, drainage recycling, and salinity concentrations.
Applications:	Regional scale model that could be used to simulate irrgation district decisions regarding drainage recycling, ground water pumping, short term storage, and direct discharge and dilution of drainage to the San Joaquin River. Performs sub-regional mass balances on the water district scale.
CALFED Potential:	Focused and refined inputs for primary assessment models.
Documentation:	Model developed from WADE package using GAMS-MINOS code for UNIX. Developed for the San Luis Drainage Program following end of San Joaquin Drainage Program.
Availability:	USBR - public domain Nigel Quinn, USBR, (916) 979-2325

Tool & Category:	SJRIO-2 (San Joaquin River Input-Output Model); Agricultural Water Quality
Purpose:	Second generation of 1986 model that simulates hydrology and water quality of San Joaquin River.
Approach:	Deterministic one-dimentsional mass-balance river flow and water quality model.
Inputs:	Flow and water quality of all flow contributions and diversions. Groundwater characteristics adjacent to the model nodes for the channel.
Methods:	Mass balance model that determines flow and water quality at 180 locations with monthly time step. Determines contribution or loss to groundwater from river stage. Model is calibrated against data at four control points. Can be run stochastically to perform Monte Carlo simulations. Model can be run with historical data, stochastic data, or both.
Results:	Surface flows, and water quality for TDS, boron, and selenium. Time series data plots of flow and water quality.
Applications:	Model used to assess effects of drainage reduction in major contributing return flows on water quality of San Joaquin River. Used to develop water quality objectives for selenium and boron.
CALFED Potential:	Regional scale model that could be used to provide more focused and refined drainage water quality inputs for primary assessment models of the Central Valley.
Documentation:	
Availability:	SWRCB and UCD - public domain Nigel Quinn, USBR, (916) 979-2325

Tool & Category:	SJRIO-DAY (San Joaquin River Input-Output Model); Agricultural Water Quality
Purpose:	Third generation of 1986 model that simulates hydrology and water quality of San Joaquin River.
Approach:	Deterministic one-dimentsional mass-balance river flow and water quality model.
Inputs:	Flow and water quality of all flow contributions and diversions. Groundwater characteristics adjacent to the model nodes for the channel.
Methods:	Mass balance model that determines flow and water quality at 180 locations with daily time step. Determines contribution or loss to groundwater from river stage. Model is calibrated against data at four control points. Can be run stochastically to perform Monte Carlo simulations. Model can be run with historical data, stochastic data, or both. A Windows based graphical user interface assists the interpretation of model results.
Results:	Surface flows, and water quality for TDS, boron, and selenium. Time series data plots of flow and water quality.
Applications:	Model currently being developed for real-time management of San Joaquin River water quality through the San Joaquin River Management Program (SJRMP). Real time river stage and EC data are being collected and sent by remote telemetry to the computer model to assess pollutant assimilation capacity of the San Joaquin River.
CALFED Potential:	Regional scale model that could be used to provide more focused and refined drainage water quality inputs for primary assessment models of the Central Valley.
Documentation:	The model is still under development.
Availability:	SWRCB and UCD - public domain Nigel Quinn, USBR, (916) 979-2325

Tool & Category:	NRWS (Natural Resources Work Station); Agricultural Water Quality
Purpose:	Model simulates stage, flow, and water quality of wetland storage operations and return flow discharges in Grasslands Basin of San Joaquin basin.
Approach:	HEC-5Q hydrodynamic mass-balance model that is integrated with GIS system and consumptive use model.
Inputs:	Stage, inflow, channel hydraulic factors (roughness, hydraulic radius), channel geometry (length, routing), water quality, and surface features (land use, vegetation, soil type, ponds)
Methods:	The system uses GIS (GRASS) to generate consumptive use and seepage for input to a HEC-5Q model. The HEC-5Q model simulates stage, flow, and concentrations of water quality parameters at a user specified time step. The GIS component can import aerial photos for defining land use and generating hydrologic input values. The system is programmed in UNIX for a SUN/AVION workstation.
Results:	Model calculates monthly water demand for vegetation types, canal discharges to wetlands, quantity and quality of water needed to meet demands, and quantity and quality of return flows.
Applications:	Model useful for planning studies of new wetland diversion and storage operations. Model can provide refined estimates of water quality in Mud Slough, Salt Slough, and San Luis Drain.
CALFED Potential	Focused and refined inputs for primary assessment models.
Documentation:	Under development, due in 1996.
Availability	Colorado St. University and USBR. Nigel Quinn, USBR, (916) 979-2325

Tool & Category:	SJRMOD (San Joaquin River Model); Agricultural Water Quality
Purpose:	Mass balance model to simulate hydrology and salt load in San Joaquin River from Vernalis to Lander Ave.
Approach:	One-dimensional river channel mass-balance model.
Inputs:	Flow and water quality for all inputs and diversions.
Methods:	Historical flow relationship based mass-balance solution for 8-segment nodal network including major tributaries. Subsurface drainage added as lump sum in three nodes along modeled reach. Ground water and diversions not accounted for. Model simulates monthly time step.
Results:	Monthly flow and TDS at each model node.
Applications:	Used to assess changes in water quality from drainage discharge.
CALFED Potential:	Focused and refined inputs for primary assessment models.
Documentation:	IBM Windows
Availability:	UC Davis - public domain Gerald Orlobb, UC Davis, (916) 752-1424

Tool & Category:	DICU (Delta Island Consumptive Use model); Agricultural Water Quality
Purpose:	Model that provides detailed spatial input on drainage, diversions, channel depletion, and return flows on Delta islands for the DWR-DSM hydrodynamic model.
Approach:	Deterministic mass-balance model developed from hydrodynamic DWR-DSM model.
Inputs:	Model requires estimates for consumptive use, precipitation, evapotranspiration, irrigation, soil moisture, leach water, runoff, crop type, and acreage.
Methods:	The model predicts consumptive use for 142 sub-areas using a soil moisture accounting routine. The model uses the 1922-1995 historical record of Delta channel flows, precipitation, and evapotranspiration. Input variables associated with each sub-area according to acreage of 20 crop and land use categories and in relation to two water year types (critical and non-critical). A sub-area to node allocation program (NODCU) partitions the model output for drainage and diversion to the DWR-DSM nodes. Salinity and chloride values are assigned according to sub-area.
Results:	The model gives monthly estimates of diversions and return flows for approximately 200 drainage and 250 diversion nodes of the DWR-DSM model.
Applications:	The model will be utilized to generate more accurate estimate of island hydrology and water quality and associated impacts on Delta ecosystem. DWR's particle tracking capabilities within the DWR-DSM model are highly sensitive to island diversions.
CALFED Potential:	The DICU model would help model the effects of island drainage water quality from CALFED alternative actions. The model is directly linked to the SWP's primary planning model and provides information critical to impact assessments of alternative land use scenarios for the Delta.
Documentation:	Model documentation available from February 1995. Model calibrations and sensitivity analyses conducted with Twitchell Island data showed reasonable accuracy. Further modifications of the model are ongoing.
Availability:	Currently under development. Francis Chung , DWR, (916) 653-5601

Tool & Category:	SWAGSIM (Soil Water and Ground Water Simulation Model); Agricultural Water Quality
Purpose:	Simulate shallow soil and ground water interactions and associated water quality in irrigated agricultural systems.
Approach:	Three dimensional finite difference mass balance model.
Inputs:	Soil physical characteristics, crop types, and hydrologic inputs.
Methods:	User defined geographic scale and time step and is programmed in Visual BASIC for IBM PC. Model accounts for consumptive use, crop type, and hydrologic inputs, and hydrologic factors for multi-layer shallow groundwater compartments.
Results:	Drainage quantity and mass balance summary between soil and ground water components of saturated soil zone.
Applications:	Currently being calibrated for use in the Grasslands area of the San Joaquin Valley for analysis of alternative irrigation practices on weekly time step.
CALFED Potential:	Could be used to provide more detailed and refined input for larger scale ground water and salt transport models.
Documentation:	Prathapar, S.A., W.S. Meyer, S. Jain, and A. Van der Leilij. 1994. SWAGSIM - A Soil and Ground Water Simulation Model. Divisional Report 94/3, Commonwealth Scientific and Industrial Research Office (CSIRO), Institute of Natural Resources and Environment, Division of Water Resources, 38 p.
Availability:	Proprietary software - S.A. Prathapar, CSIRO -Griffith, Australia Contact: Jim Ayars, USDA Agricultural Reseach Service, Water Management Research Laboratory, Fresno, CA, (209) 453-3100

Tool & Category:	DeltaDWQ (Delta Drainage Water Quality model) Agricultural Water Quality
Purpose:	DeltaDWQ used to evaluate effects of Delta Wetlands Project on island drainage and Delta channel water quality.
Approach:	Lotus 1-2-3 based spreadsheet mass-balance model.
Inputs:	Initial monthly Delta hydrologic and water quality characteristics for 1967-1991 from DeltaSOS model; estimated island water applications, consumptive use, losses, soil moisture, drainage, and salt and dissolved organic carbon (DOC) budget terms.
Methods:	Model accounts for water, salt, and DOC budgets for three Delta Island land types (open water, upland agricultural, and lowland agricultural). For each land type, model accounts for consumptive use, evapotranspiration, leaching, soil moisture storage, drainage, and water quality factors (EC, DOC). Portion of channel flows and exports that are associated with Delta Wetland island drainage are based on RMA hydrodynamic model results. Model simulates with monthly time step.
Results:	Monthly values for Delta channel and export pump concentrations of EC and DOC.
Applications:	Used to describe water quality impacts from in-Delta storage operations for Delta Wetlands project on Bouldin, Bacon, Webb Tract, and Holland Tract islands.
CALFED Potential:	Could be used to describe typical island drainage water quality under alternative CALFED actions.
Documentation:	Appendix C3 "Delta Drainage Water Quality Model" in Delta Wetlands Project Draft EIR/EIS (SWRCB & COE 1995).
Availability:	Free-access Russ T. Brown, Jones & Stokes Associates, (916) 737-3000

Tool & Category:	Delta THM Formation Potential Model; Drinking Water Quality
Purpose:	Calculates the trihalomethane (THM) formation potential of Delta water supplies that are to be treated at municipal drinkng water treatment plants.
Approach:	Deterministic concentration balance sub-model of hydrodynamic DWR-DSM model.
Inputs:	Base conditions of channel hydrology (i.e., flow, stage, and channel characteristics) and water quality (i.e., dissolved organic carbon, temperature, and pH) are derived from DWR-DSM hydrodynamic model.
Methods:	Model utilizes DWR-DSM model to simulate THM formation potential at the export locations. Model accounts for concentrations of precursors (DOC, Cl, Br), bromine incorporation factor, and four primary THMs. Generally utilized with monthly time step.
Results:	Model calculates monthly precursor and bromide concentrations, and THM formation potential at Delta export locations.
Applications:	Used to identify the THM formation potential in water exported from the Delta that is bound for municipal drinking water supplies.
CALFED Potential:	Could be used to predict the effects of alternative CALFED actions on the quality of municipal drinking water supplies and associated costs of treatment.
Documentation:	Model has been calibrated for bromine incorporation and distribution factors, and THM formation potential against a data base of over 2000 Delta water samples.
Availability:	Francis Chung, DWR, (916) 653-5601

Tool & Category:	**WASP4**	**Water Quality**

Purpose:	Simulate water quality variables over space and time.
Approach:	Dynamic compartment, mass balance model.
Inputs:	Simulation and output control specifications, model segmentation, advective and dispersive transport coefficients, boundary concentrations, point and diffuse source waste loads, kinetic parameters, constants and time functions, and initial concentrations.
Methods:	Numerical integration of finite-difference mass balance equations linked to output from link-node type hydrodynamic model (DYNHYD4).
Results:	Time series of dissolved and particulate constituent concentrations in each model segment. Submodel EUTRO4 simulates nutrients, phytoplankton, carbonaceous material, and dissolved oxygen dynamics. Submodel TOXI4 simulates synthetic organic compounds and trace elements.
Applications:	Used in lakes (e.g., Lake Ontario), rivers (e.g., Upper Mississippi River), and estuaries (e.g., Potomac).
CALFED Potential:	Could be used to describe existing water quality conditions on finer spatial and temporal scale than empirical models based on monitoring data. Could provide basis for general predictions of water quality conditions in subdivisions of Bay-Delta system or for site-specific predictions near points of particular concern.
Documentation:	"WASP4, A Dynamic Hydrodynamic and Water Quality Model--Model Theory, User's Manual, and Programmer's Guide," EPA/600/3-87/039, January 1988.
Availability:	Public domain. Available from Center for Exposure Assessment Modeling, Environmental Research Laboratory, USEPA, Athens, GA 30613-0801. Catherine E. Green, (706) 546-3210, 546-3340 (fax).

Tool & Category:	**Water Quality Surveillance Program**	**Water Quality**

Purpose: Document water quality conditions at 28 monitoring stations and benthic biota and substrate composition at 5 monitoring stations in the Sacramento-San Joaquin Delta.

Approach: Fixed station with periodic sampling schedule.

Inputs: N/A

Methods: Water samples are collected from boats using submersible pumps or from piers using Van Dorn samplers. Benthic samples are collected with a Ponar device (0.053 m^2). Properties are measured according to standard methods.

Results: Data are available from 1975 to present. Variables measured in the field include water depth, temperature, dissolved oxygen, specific conductance, pH, alkalinity, turbidity, light transmittance, Secchi depth, air temperature, wind speed, and general weather conditions. Laboratory measurements include total dissolved solids, total and volatile suspended solids, total ammonia-N, dissolved nitrate-nitrite-N, Kjeldahl N, dissolved orthophosphate-P, total P, BOD, COD, chloride, silica, heavy metals (As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Zn), pesticides, PCB's, chlorophyll, and phaeopigments. Organisms collected in Ponar samples are enumerated and identified to species. Substrate material is classified visually (e.g., "organic silty clay") and analyzed for percent gravel, sand, silt-clay, and organic content (weight loss on ignition).

Applications:

CALFED Potential: Could be used to document historical conditions, to perform comparative analyses, time series analyses, and as a tool for calibrating or evaluating water quality models.

Documentation: Data are tabulated in a series of annual reports entitled "Sacramento-San Joaquin Delta Water Quality Surveillance Program, (year), Monitoring Results Pursuant to Delta Water Rights Decision 1485." Department of Water Resources, Sacramento. Recent reports consist of three volumes. Volume I contains methodology, field data, and lab data. Volume II contains phytoplankton densities and taxonomy (to genus). Volume III contains data on substrate composition and the abundance and taxonomic composition of benthic organisms.

Availability: Name and address of person from whom software can be obtained and person in charge of support.

Tool & Category:	**National Stream Quality Accounting Network Water Quality**
Purpose:	Document physical and chemical properties of streams at routine monitoring stations throughout the U.S.
Approach:	Fixed station with periodic sampling schedule.
Inputs:	N/A
Methods:	Depth integrated water samples are collected at several points along a fixed transect. Samples are usually collected monthly and analyzed using standard methods. Bed material samples are also collected at some stations, usually at least twice a year.
Results:	Data for the Sacramento River at Keswick and the San Joaquin River at Vernalis are available from 1975 to present. Variables measured in the field include instantaneous discharge, water temperature, dissolved oxygen, barometric pressure, fecal coliform and streptococci bacteria. Laboratory measurements include specific conductance, pH, alkalinity, turbidity, total hardness, noncarbonate hardness, dissolved calcium, magnesium, sodium, potassium, bicarbonate, carbonate, alkalinity, sulfate, chloride, fluoride, silica, total dissolved solids, nitrite-N, nitrate-N, ammonia-N, Kjeldahl N, total P, dissolved P, orthophosphate P, aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, zinc. Also measured are suspended sediment concentration and particle size distribution as well as particle size distribution of Bed material.
Applications:	
CALFED Potential:	Could be used (in combination with daily discharge records) to estimate constituent loads to Delta, in comparative analyses, time series analyses, and as a tool for calibrating or evaluating water quality models.
Documentation:	NASQAN data for a given water year are tabulated in a series of annual reports entitled "Water Resources Data, California" published by the U.S. Geological Survey.
Availability:	Data are available via ftp from the U.S. Geological Survey, Water Resources Division.

Tool & Category:	**SWP Water Quality Monitoring Program**	**Water Quality**

Purpose: Document physical and chemical properties of water stored and conveyed by State Water Project facilities, document long-term changes in SWP water quality, provide SWP contractors with water quality data to assess water treatment plant operational needs, and assess the influence of hydrological conditions and water operations on SWP water quality.

Approach: Fixed station with periodic sampling schedule.

Inputs: N/A

Methods: Water samples are collected mid-channel at 33 stations, usually once a month. Chemical analyses are performed according to standard methods.

Results: Data for some stations are available from 1968 to present. Variables measured vary among stations. Temperature, dissolved oxygen, pH, conductivity, in vivo fluorescence, various mineral constituents (e.g., Ca, Mg, Na, K, etc.), heavy metals, phosphorus and nitrogen, total and volatile suspended solids, settleable solids, BOD, COD, total organic carbon, various pesticides and other synthetic organic compounds are measured at principal stations.

Applications: Concentration data are compared with Article 19 objectives or Department of Health Services Drinking Water Standards.

CALFED Potential: Could be used (in combination with daily discharge records) to estimate constituent loads exported from Delta; to examine relation between in-Delta conditions and SWP water quality; and to calibrate or evaluate water quality model predictions.

Documentation: Select data for 11 stations are published in a series of reports entitled "State Water Project Water Quality" published by the California Department of Water Resources.

Availability: Data are available from the Division of Operations and Maintenance, Water Quality Section (Larry Joyce, 916-653-7213).

Tool & Category:	**Toxic Substances Monitoring Program**	**Water Quality**

Purpose: To provide a uniform statewide program for detecting and evaluating occurrence of toxic substances in fresh and estuarine waters of the state.

Approach: Fixed stations sampled once a year for trend analysis; other stations sampled by request from regional boards or other agencies.

Inputs: N/A

Methods: Composite samples are collected from tissues of local fish (especially predators) or transplanted asiatic clams. Six specimens are usually collected per site. Occasionally, phytoplankton, turtles or other organisms may be collected. Some sediment analyses are also performed using standard methods.

Results: Results are available for 1978 to present. Number and location of stations sampled, specific organisms collected, and analytes measured vary among years. Generally, samples are analyzed for trace elements (e.g., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc) and synthetic organic compounds (e.g., chlordane, chlorpyfifos, dacthal, DDT, dieldrin, endosulfan, HCB, HCH, methoxychlor, PCBs, PCP and TCP, PAHs, toxaphene). Results are reported on a fresh weight and lipid weight basis.

Applications: Concentration data are compared with data collected at same location during previous years and with U.S. Food and Drug Administration Action Levels, National Academy of Sciences Guidelines, United Nations Food and Agriculture Organization Median International Standards for trace elements or tissue-specific "elevated data level" percentile values based on all samples collected over entire period of record. Results are forwarded to regional boards and the California Department of Health Services.

CALFED Potential: Many sites are located on the Sacramento and San Joaquin rivers and some of their tributaries as well as in some Delta channels and Suisun Bay. Concentrations of selected constituents could be compared to loading rates to the Bay-Delta to develop empirical models or to perform multi variate or other statistical analyses.

Documentation: Data are published in annual reports entitled "Toxic Substances Monitoring Program, Water Quality Report" by the California State Water Resources Control Board.

Availability: Data are available from the State Water Resources Control Board.

Tool: San Francisco Estuary Regional Monitoring Program for Trace Substances

Category: River and Delta Water Quality

Purpose: Monitor the status and trends of contaminants in the Estuary, evaluate compliance with water quality standards, and provide trace substances data for other users.

Approach: Fixed station, sampled 2 or 3 times a year.

Inputs:

Methods: Samples of Estuary water, sediment, and the tissues of transplanted bivalves are collected 2 or 3 times a year from up to 24 stations located between Coyote Creek in the South Bay and the confluence of the Sacramento and San Joaquin rivers. Stations are generally located in the main channels, but some stations are located at the mouths of other major tributaries or in the shallows.

Results: Program began in 1993. Data include water quality (salinity, suspended solids, DOC, nutrients, etc.), sediment grain size and organic carbon content, and a full suite of contaminants in water and sediments. Two aquatic bioassays (using mysids and larval bivalves) and tow sediment bioassays (using amphipods and larval bivalves) are conducted twice each year.

Applications:

CALFED Potential: Could be used to help characterize existing conditions in the Bay-Delta and to calibrate or evaluate models for predicting future conditions.

Documentation: A descriptive annual report is published by the San Francisco Estuary Institute.

Availability: Oracle data base available from Bruce Thompson, SFEI, (510) 231-9539, brucet@sfei.org.

Tool: South Bay Dischargers Authority Water Quality Monitoring Program

Category: Water Quality

Purpose: Document the net impact of continued SBDA discharges on beneficial uses and water quality in the South Bay and to examine enhancement of the South Bay environment as a result of the discharges.

Approach: Fixed station at sampling frequencies ranging from daily (plant effluent) to quarterly (sediment chemistry).

Inputs:

Methods: Each SBDA member monitors its effluent daily as required under NPDES permit. Receiving waters are monitored biweekly at 24 stations in South San Francisco Bay (south of Dumbarton Bridge). Sediment and water column monitoring is conducted quarterly at four stations. Bay shrimp (Crangon franciscorum) are collected monthly at five stations and sorted by sex and reproductive state, then counted, weighed and examined for parasites and tumors or other abnormalities. Ten-minute otter trawls are performed monthly to sample fish population abundance and species richness at five stations. Shrimp tissue samples are collected and analyzed for trace metal content each quarter. Benthic invertebrates are sampled semiweekly at five stations in Artesian Slough and Coyote Creek from June 15 to October 15 and analyzed for presence of Clostridium botulinum Type C.

Results: Five year program began in 1980. Effluent monitoring includes flow, BOD, suspended solids, ammonia, ultimate oxygen demand, dissolved oxygen, nitrate, phosphate, oil and grease, and trace metals. Variables measured in receiving waters include salinity, pH, Secchi depth, turbidity, temperature, color, dissolved oxygen, ammonia, nitrate-nitrite, total organic N, total P, dissolved sulfides, and coliform bacteria. Sediment samples are analyzed for trace metals, phenolic compounds, total identifiable chlorinated hydrocarbons, and total organic carbon. Also reported are the results of special shorter term studies including laboratory studies of the effects of SBDA effluents on the growth of the macroalga Polysiphonia sp, studies to quantify and map vegetation types and census bird populations in marsh areas surrounding SBDA discharge points, and studies documenting gut contents of local fish. Analysis includes comparisons with historical data, some of which extends back to early 1960s, and comparisons between reference stations and stations influenced by SBDA effluent.

Applications: Data are presented in annual technical reports to the SBDA board.

CALFED Potential: Could be used to help characterize existing conditions in South Bay and to calibrate models for predicting future conditions.

Documentation: Annual reports entitled "South Bay Dischargers Authority Water Quality Monitoring Program, Technical Report."

Availability: Available from South Bay Dischargers Authority, Room 300, City Hall, First and Mission Streets, San Jose, CA 95110.

Tool & Category: **Stockton Dissolved Oxygen Model - Systech; Hydrodynamics, Water Quality.**

Purpose: Simulate dissolved oxygen in the San Joaquin River around Stockton.

Approach: One-dimensional, link-node model based on Fischer's model (method of characteristics/Lagrangian transport).

Inputs: San Joaquin River discharge at Vernalis; tides at Venice Island; Stockton WWTP effluent discharge; water quality (DO, ammonia, CBOD, nitrate, TSD, coliform) of San Joaquin, tides, and effluent.

Methods: Hydrodynamic model generates flow data for water quality model, estimate San Joaquin River discharge at Stockton w/ and w/o barrier at Old River and for pumping conditions, calculate velocities, elevations at 40-second time step; water quality model accounts for pollutant advection, diffusion, sinks and sources associated with biological and chemical reactions.

Results: Elevations, concentrations at nodes, flow for links

Applications: San Joaquin River at Stockton.

CALFED Potential: Uncertain.

Documentation: Philip Williams & Associates and Systech Engineering, 1993. City of Stockton water quality model, Volume I: model development and calibration.

Availability:

Tool & Category:	Municipal Water Quality Investigations (MWQI) Program; Drinking Water Quality
Purpose:	Monitoring program initiated by DWR in 1983 to study the quality of Delta water as a source for drinking water supplies.
Approach:	Water quality monitoring and data collection program.
Inputs:	Funding by DWR Division of Local Assistance.
Methods:	Monthly monitoring conducted for numerous Delta channels and drainage return flows. Samples are collected as mid-channel, depth integrated / surface grabs.
Results:	Monthly monitoring at numerous Delta channel and island return flow locations for conventional parameters, minerals, sodium, asbestos, disinfection byproducts such as THMs, organic materials, and pesticide residues.
Applications:	The MWQI data base is an important historical record of drainage and Delta channel water quality that is used to provide input for Delta modeling efforts of THM precursor transport and formation potential.
CALFED Potential:	The MWQI data base can aid the CALFED alternatives analysis by providing information on expected drinking water quality from varying hydrology and water quality scenarios.
Documentation:	Published records include a five year progress report (DWR 1994).
Availability:	The data are available on EPA's STORET data base.

Tool: THM formation potential model using artificial neural network

Category: Drinking Water Treatment

Purpose: Simulate trihalomethane formation potential in state water supply system.

Approach: Artificial Neural Network (ANN) with log sigmoid transfer function.

Inputs: Bromide concentration, product of dissolved organic carbon concentration and UV absorbance at 254 nm, available chlorine dose, reaction time, temperature, and pH.

Methods: A feed-forward ANN (Stuttgard Neural Network Simulator), with 5 neurons in the first hidden layer and three neurons in the second hidden layer is trained to minimize the sum-of-squares error between observed and predicted values. A log sigmoid function is specified as the activation or transfer function. Prior to training, input calibration data are log transformed.

Results: Predicted total THM formation and individual species concentrations.

Applications: May be incorporated as a post-processor into DWR DSM2 model.

CALFED Potential: Could be incorporated into EPA Water Treatment Plant model.

Documentation: None

Availability: ANN code is public domain. Contact Paul Hutton (DWR) at (916) 653-5666 for more information.

Tool & Category:	**California Natural Diversity Data Base (NDDB) Vegetation & Wildlife**
Purpose:	Document occurrences of special status plant and animal species and special status natural communities in California.
Approach:	Reports of special status species occurrences are submitted to DFG on standard data forms by the public and agency personnel. Other records are based on published observations in scientific articles.
Inputs:	N/A
Results:	Results are available from the early part of the century to present. Location (utm coordinates, township-range-section), mapping accuracy, estimated population size, habitat characteristics, land ownership, threats, legal protection status, date of observation, and name of source.
Application:	NDDB data are used for a wide range of natural resource planning applications, including EIRs/EISs, resource management plans, regional biodiversity planning and others.
CALFED potential:	Could be used in impact analysis of actions that may affect listed threatened or endangered species, species of special concern to DFG and other special status species and special status communities. Data could also be used to help guide protection efforts and special status species mitigation.
Documentation:	Data are available as point and region feature classes in ARC/INFO Geographic Information System (GIS) coverages and in FoxBase data bases that are annually updated. The GIS data are accompanied by extensive meta data.
Availability:	Data are available in electronic form from The Natural Heritage Division of DFG.

Tool and Category:	Salmonid Flow/Habitat Indices Fisheries
Purpose:	Estimate the effects of flow conditions on habitat for several life stages of steelhead and chinook salmon under different simulated flow regimes in the Sacramento-San Joaquin basin.
Approach:	
Inputs:	Simulated flow conditions in applicable reaches or tributaries and flow/habitat relationships.
Methods:	Simulated flow conditions in a reach or tributary are combined with flow/habitat relationships to estimate the amount of habitat under different flow conditions. Flow/habitat relationships are of two types: 1) Proportional Habitat Indices are subjective, *ad hoc* linear relationships developed for the CVPIA PEIS, and 2) Weighted-Usable-Area Habitat Indices are derived from instream flow studies. A provision is also included for modeling pulse flows for juvenile and adult migration.
Results:	The results produced by these models are the estimated effects of flow conditions on habitat for various life stages of steelhead trout and chinook salmon in reaches and tributaries within the basin.
Applications:	Results from these models can be used to determine the potential effects of river flow regimes on habitat conditions for salmonid life stages in reaches or tributaries within the basin.
CALFED Potential:	Low potential for use in CALFED programs because the effects modeled occur entirely outside the Delta.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Salmonid Habitat Restoration Indices Fisheries
Purpose:	Estimate the effects of three categories of habitat restoration activities (spawning/incubation, rearing, and riparian restoration) on habitat conditions for applicable life stages of steelhead and chinook salmon reaches or tributaries within the Sacramento-San Joaquin basin.
Approach:	
Inputs:	Estimates of the area of habitat restored and the amount of available habitat in the reach or tributary before restoration activities.
Methods:	Estimates of the area of habitat restored in a given reach or tributary are expressed as a proportion of the amount of available habitat to provide an index of benefits to fish populations. The three categories of habitat restoration are assumed to be of equal value, and benefits to fish populations are assumed to be in direct proportion to increased habitat availability.
Results:	The results produced by this model are the estimated benefits to steelhead trout and chinook salmon populations from habitat restoration in reaches and tributaries within the basin.
Applications:	Results from this model can be used to estimate the potential effects of habitat restoration on salmonid populations in reaches or tributaries within the basin.
CALFED Potential:	Low potential for use in CALFED programs because the effects modeled occur entirely outside the Delta.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Habitat Suitability Indices (HSI) Fisheries
Purpose:	Estimate the suitability of a given habitat for a given fish species based on habitat variables.
Approach:	
Inputs:	Habitat variables.
Methods:	HSI models are designed to determine the 'suitability' of a given habitat for a fish species based on habitat variables. Relationships between habitat variables and habitat 'suitability' are usually derived from literature sources, expert opinion, or field observations of habitat use. These indices are available for most economically important species of fish in coastal and inland waters.
Results:	The result produced by these models is the suitability of a given habitat for the particular life stage of the species under consideration.
Applications:	Results from this model can be used to estimate the potential effects of changes in a number of habitat variables (e.g. depth, velocity, substrate, cover, DO, temperature, etc.) on fish species.
CALFED Potential:	Moderate potential for use in CALFED programs.
Documentation:	Stier, D.J., and J.H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U.S.F.W.S. Biological Report 82(10.88). Bain, M.B., and J.L. Bain. 1982. Habitat suitability index models: coastal stocks of striped bass. FWS/OBS-82/10.1 Raleigh, R.F., W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S.F.W.S. Biological Report 82(10.122).
Availability:	U.S. Fish and Wildlife Service, 2800 Cottage Way, Sacramento, CA 95825.

Tool: HYDROQUAL

Category: Primary and Secondary Production

Purpose: Simulate phytoplankton dynamics in San Francisco Bay estuary.

Approach: Deterministic, mass balance.

Inputs: Requires calibrated hydrodynamics model, solar radiation, temperature, nutrient concentrations, and assigned values of algal growth rate, settling rate, nutrient uptake rate, and other kinetic coefficients.

Methods: Numerical integration of finite-difference mass balance equations linked to output from hydrodynamic model.

Results: Time series of chlorophyll or algal particulate organic carbon concentration at each model segment.

Applications: Has been calibrated for Bay (mid-1970s), but not for Delta.

CALFED Potential: Could be applied to Delta if linked to suitable hydrodynamic model.

Documentation: Unpublished reports at Bureau of Reclamation.

Availability: Douglas Ball, Bureau of Reclamation, Sacramento, CA.

Tool: National Stream Quality Accounting Network Phytoplankton Data

Category: Primary and Secondary Production

Purpose: Document abundance of sestonic algae in streams at routine monitoring stations throughout the U.S.

Approach: Fixed station with periodic sampling schedule.

Inputs: N/A

Methods: Depth integrated water samples are collected at several points along a fixed transect. Samples are usually collected monthly and analyzed using standard methods.

Results: Data for the Sacramento River at Keswick and the San Joaquin River at Vernalis are available from 1974 to 1981. Abundance (Cells/mL) and taxonomic composition (genus) are reported for each sample.

Applications:

CALFED Potential: Could be used to characterize sestonic algal community structure in CentralValley rivers and (in combination with daily discharge records) to estimate algal biomass loading to Delta.

Documentation: NASQAN data for a given water year are tabulated in a series of annual reports entitled "Water Resources Data, California" published by the U.S. Geological Survey.

Availability: Data are available via ftp from the U.S. Geological Survey, Water Resources Division.

Tool: IEP Neomysis/Zooplankton Project

Category: Primary and Secondary Production

Purpose: Monitor abundance of Neomysis mercedis and zooplankton in the Sacramento-San Joaquin estuary, including San Pablo Bay, Carquinez Strait, Suisun Bay, the Sacramento River upstream to Hood, the San Joaquin River upstream to Stockton and the southern Delta to Clifton Court.

Approach: Fixed station, generally with monthly sampling schedule.

Inputs:

Methods: Neomysis net (1mm silk bolting cloth) and Clarke-Bumpus net (No. 10 nylon) used with current meter to estimate volume of water sampled. Samples preserved in 10% formalin solution with Rose Bengal dye. A subsample of mysids is measured (length from eye to base of telson) and classified as juvenile, gravid female, non-gravid female or male. Concentrated zooplankton subsamples are placed in a Sedgwick-Rafter cell, counted, and identified using a compound microscope

Results: Neomysis data available for 1968 to present; zooplankton, since 1972. Data are reported as numbers of organisms per cubic meter. 81 stations have been sampled since the project began, but only 35 sites have been sampled every year since 1968.

Applications:

CALFED Potential: Could be used to help characterize existing conditions in the Bay-Delta and to calibrate or evaluate models for predicting future conditions.

Documentation: Reference collection housed at California Department of Fish and Game, Bay-Delta Division, 4001 N. Wilson Way, Stockton, CA 95205.

Availability: Available from James Orsi (209) 942-6087 or via IEP web site, http://wwwiep.water.ca.gov.

Tool: IEP Delta Outflow/San Francisco Bay Study

Category: Primary and Secondary Production

Purpose: Determine the effects of freshwater outflow on the abundance and distribution of fish, caridean shrimp, and Cancer crabs in San Francisco Bay/Estuary.

Approach: Fixed station, with monthly sampling schedule.

Inputs:

Methods: Organisms are collected from open water sites with an otter trawl, midwater trawl and plankton net. Beach seines are used at near-shore stations. Crabs are collected using ring nets. Fish, shrimp, and crabs are identified to species, measured and counted. Sex is also determined for shrimp and crabs. For shrimp, egg and ovary stages are determined and presence of the branchial parasite Argiea and food in the stomach are noted.

Results: Data are available from 1980-present for open water stations, 1980-1987 for beach seining sites, and 1982-present for ring net sites. 35 open water sites have been sampled every year since 1980. 27 shorline sites were sampled with beach seines.

Applications:

CALFED Potential: Could be used to help characterize existing conditions in the Bay-Delta and to calibrate or evaluate models for predicting future conditions.

Documentation: Reference collection housed at California Department of Fish and Game, Bay-Delta Division, 4001 N. Wilson Way, Stockton, CA 95205.

Availability: Available from Kathryn Hieb (209) 942-6087 or via IEP web site, http://wwwiep.water.ca.gov.

Tool and Category:	Delta Fish Transport Indices Fisheries
Purpose:	Estimate the potential movement of fish eggs and larvae from spawning habitat to preferred rearing habitat for a given set of Delta conditions.
Approach:	
Inputs:	Spawning locations of species, Delta flow patterns (ebb and flood flows).
Methods:	Information about the spawning locations of striped bass, Delta smelt, and longfin smelt are combined with data describing flow patterns among eight 'habitat units' (Lower Sacramento River, Confluence, Suisun Bay, Suisun Marsh, Lower San Joaquin River, Mokelumne River, South Delta, Honker Bay) within the Delta.
Results:	The result produced by this model is the estimated distribution of eggs and larvae of the three species in the eight 'habitat units' in the Delta. This model also estimates the number of eggs and larvae entrained in diversions.
Applications:	Results from this model can be used to evaluate potential changes in the distribution of eggs and larvae of striped bass, Delta smelt, and longfin smelt under various Delta conditions and water project operation scenarios.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Salmonid Diversion Indices Fisheries
Purpose:	Estimate the losses to salmonid populations resulting from water diversions in the Sacramento-San Joaquin basin.
Approach:	
Inputs:	Proportion of river or Delta channel flow diverted, proportion of a species/race migrating past diversions, river and Delta water flow data, cross Delta flow index, water temperature.
Methods:	These models attempt to estimate the loss to salmonid populations from diversions by combining information about proportions of flow diverted and proportions of a given species or race that migrate past applicable diversions. The loss of salmonids at diversions is assumed to be directly related to the proportion of flow diverted; a correction factor is applied to screened diversions. Distribution of migrating salmonids among the many complex pathways that exist in the lower Sacramento and San Joaquin are assumed proportional to flow. Riverine and Delta diversion losses are estimated separately.
Results:	The results produced by these models are the estimated losses to steelhead trout and chinook salmon populations resulting from water diversions within the basin.
Applications:	Results from this model can be used to estimate the potential effects of water diversions on salmonid populations in reaches or tributaries within the basin.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Delta Diversion Indices Fisheries
Purpose:	Estimate the losses to screenable life stages of striped bass, Delta smelt, longfin smelt, Sacramento splittail, American shad, and green and white sturgeon populations resulting from water diversions in the Delta.
Approach:	
Inputs:	Proportion of Delta channel flow diverted, distribution of species among migration pathways, Delta water flow.
Methods:	These models attempt to estimate the losses to Delta fish populations from diversions by combining information about proportions of flow diverted and proportions of a given species that migrate past applicable diversions. The loss of fish at diversions is assumed to be proportional to the volume of flow diverted; a correction factor is applied to screened diversions. Distribution of fish among the many 'pathways' in the Delta is calculated separately for each species.
Results:	The results produced by these models are the estimated losses of screenable life stages of fish populations resulting from water diversions within the Delta.
Applications:	Results from this model can be used to estimate the potential effects of water diversions on screenable life stages of fish populations in the Delta.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Chinook Salmon Population Model (CPOP-2) Fisheries
Purpose:	Estimate the effects of changes in flow, temperature, toxins, or natural and fishing mortality rates on the population dynamics of fall-run chinook salmon stocks in the Sacramento River system.
Approach:	
Inputs:	Streamflow information for reaches in the Sacramento basin. User can also change a number of parameters in the model, including temperature, concentration of toxins, and various mortality rates.
Methods:	CPOP is a large, complex deterministic model that simulates Sacramento River fall-run chinook salmon population dynamics throughout the entire life cycle. A variety of natural and human-induced mortality rates are initially set based on literature information, but a number of these may be changed by the user. The model was developed primarily to simulate the effects of changes in streamflow on Sacramento fall-run chinook, but it can also be used to simulate the effects of changes in other factors (e.g. temperature, fishing mortality, diversion mortality, etc.), including several in the Delta.
Results:	The results produced by this model are the simulated population dynamics of Sacramento River fall-run chinook under various user-specified conditions.
Applications:	Results from this model can be used to estimate the potential effects of changing streamflow, temperature, and other factors on Sacramento River fall-run chinook salmon.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Kimmerer, W., J. Hagar, J. Garcia, and T. Williams. 1989. Chinook salmon population model for the Sacramento River Basin. Version CPOP-2. Submitted to California Department of Fish and Game, Sacramento.
Availability:	California Department of Fish and Game, Sacramento, CA.

Tool and Category:	San Joaquin River Chinook Salmon Population Model (EACH)
Purpose:	Simulate the population dynamics of fall-run chinook salmon in the San Joaquin basin
Approach:	
Inputs:	Streamflow information for reaches in the San Joaquin basin.
Methods:	EACH is a large, complex model that simulates San Joaquin Basin fall-run chinook salmon population dynamics throughout the entire life cycle. The model consists of a large set of finite difference equations describing survival throughout the life cycle of San Joaquin fall-run chinook, and incorporates mortality due to a number of factors, including ocean fishing. The model is primarily driven by flow and water export variables.
Results:	The results produced by this model are the simulated population dynamics of Sacramento River fall-run chinook under various (primarily flow-related) user-specified conditions.
Applications:	Results from this model can be used to estimate the potential effects of a number of factors, including streamflow and water exports, ocean fishing, habitat improvement, and hatchery operations, on San Joaquin River fall-run chinook salmon.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	EA Engineering, Science, and Technology. 1991. San Joaquin River System Chinook Salmon Population Model Documentation. Submitted to Turlock Irrigation District.
Availability:	Turlock Irrigation District, 333 E. Canal Drive, Turlock, California 95381.

Tool and Category:	Salmonid Distribution Model Fisheries
Purpose:	Describe the spatial and temporal distribution of the various life stages of steelhead and several races of chinook salmon in the Sacramento-San Joaquin basin.
Approach:	
Inputs:	Run timing and spatial distribution of the species and races under consideration.
Methods:	Information about the spatial distribution (e.g. the proportion of fish that spawn in a given reach of a stream) of a given life stage for each race is combined with run timing information to produce monthly estimates of the distribution of each species/race within the basin.
Results:	The results produced by this model are the monthly distribution of eight life stages (adult migration, adult holding, spawning, egg and alevin incubation, fry rearing, fry dispersal, juvenile rearing, and juvenile migration) of steelhead trout and five races of chinook salmon (winter-run, late-fall-run, spring-run, Sacramento River fall-run, and San Joaquin fall-run).
Applications:	Results from this model can be used to determine the potential effects of activities throughout the basin on the salmonid species/races under consideration.
CALFED Potential:	Low potential for use in CALFED programs because the majority of the spatial distribution of these species is outside the Delta.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Salmonid Temperature Indices Fisheries
Purpose:	Estimate the survival of several life stages of steelhead and chinook salmon under different simulated temperature regimes in the Sacramento-San Joaquin basin.
Approach:	
Inputs:	Literature-derived temperature-survival relationships for the applicable life stages, results from USBR temperature models, and information regarding species distribution within the basin, including results from the Salmonid Distribution Model (see above).
Methods:	The spatial and temporal distribution of a given life stage for each species is combined with results from temperature models and temperature-survival relationships to produce monthly estimates of the survival of each species/race within the basin.
Results:	The results produced by this model are the estimated survival of eight life stages (spawning, eggs, alevins, adult migration, fry rearing, juvenile rearing, and juvenile emigration/smoltification) of steelhead trout and chinook salmon in 'watershed compartments' (tributaries or reaches) throughout the basin.
Applications:	Results from this model can be used to determine the potential effects of water temperatures throughout the basin on the salmonid species under consideration.
CALFED Potential:	Low potential for use in CALFED programs because the majority of the spatial distribution of these species is outside the Delta.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Bay/Delta Fishes Distribution Data	Fisheries

Purpose: Describe the spatial and temporal distribution of the several species of fishes in San Francisco Bay, the Delta, and the lower San Joaquin and Sacramento Rivers.

Approach:

Inputs: N/A

Methods: The California Department of Fish and Game routinely samples the abundance of Delta fishes. There are three distinct sampling programs: the summer tow net survey (tow nets; June and July; 1959-present, except for 1966), the autumn midwater trawl survey (midwater trawls; September-December; 1967-present; not all months sampled in all years) and the Bay survey (midwater and otter trawls; all months; 1980-present). Fish captured during these surveys include juvenile striped bass, delta smelt, longfin smelt, and Sacramento splittail. The Bay survey also catches more strictly marine fish and invertebrates, such as starry flounder, Pacific herring, shiner perch, Dungeness crab, and Bay shrimp.

Results: The results produced by this sampling program are the monthly catches of several fish and invertebrate species at a number of locations in the Bay and Delta.

Applications: Results from this sampling program can be used to determine the spatial and temporal distributions of various species within the Bay and Delta, and to correlate the relative abundance of Delta fishes with other environmental variables.

CALFED Potential: High potential for use in CALFED programs.

Documentation:

Availability: California Department of Fish and Game, Sacramento, CA.

Tool and Category:	Overflow Habitat Index Fisheries
Purpose:	Estimate the amount of flood basin inundation, which is assumed to be beneficial to Sacramento splittail populations because of increased spawning habitat.
Approach:	
Inputs:	Sacramento River flow conditions.
Methods:	Sacramento River flow conditions are used to estimate the amount of area of inundated floodplain in critical areas (Sutter and Yolo bypass). Inundation of these areas is assumed to be important for splittail spawning.
Results:	The result produced by this model is the amount of flooded habitat, expressed as an index, that is available for splittail spawning.
Applications:	Results from these models can be used to determine the potential effects of river flow regimes on spawning habitat conditions for Sacramento splittail.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Tool and Category:	Delta Habitat Indices Fisheries
Purpose:	Estimate the amount (surface area) of habitat within the salinity tolerance range of a number of important estuarine fishes and invertebrates in the Delta.
Approach:	
Inputs:	Delta outflow data.
Methods:	Delta outflow data are used to estimate the estuarine salinity distribution and the surface area of optimal salinity habitat for a variety of Delta species.
Results:	The results produced by this model are the relative areas of 'optimal salinity habitat' for striped bass, Delta smelt, longfin smelt, starry flounder, English sole, white croaker, northern anchovy, Pacific herring, and four invertebrate species *(Crangon francisconum, Crangon nigricauda, Neomysis mercedis, and Eurytemora affinis)* under different Delta outflow conditions.
Applications:	Results from this model can be used to estimate the area of habitat with suitable salinity to support any species for which salinity tolerance data are available.
CALFED Potential:	High potential for use in CALFED programs.
Documentation:	Central Valley Project Improvement Act Programmatic Environmental Impact Statement. Working Paper #3 Impact Assessment Methodology for Fish. December 1994 - Draft.
Availability:	Jones and Stokes Associates, Inc. Warren Shaul (916) 737-3000

Name and Resource Category: CVPOWER.ISM. Power Model

Purpose: CVPOWER.ISM was developed by the Western Area Power Administration (Western) to determine the optimal long-term energy generation capability of the CVP system. The model was designed to operate within the monthly operational criteria established by Reclamation in order to determine power generation optimization potential within the CVP system, particularly with regard to the Shasta and Trinity facilities.

Approach: This model uses Reclamation's initial forecasts of CVP water supply deliveries to project optimal CVP energy generation capability. In attempting to optimize energy generation, the model provides more operational flexibility relative to Reclamation's long-term operations studies.

Inputs: Input data to this model include 70-year inflow data to the CVP system, required CVP releases for flood control and power plants, as well as other regulatory releases.

Methods: CVPOWER.ISM is an arithmetic model that provides monthly simulations of optimal CVP power generation. The model treats each power generation facility within the CVP system distinctly, assuming various hydrologic scenarios, to project optimal power generation capacity within the CVP system.

Results: This model was developed to identify additional power generation capacity of the CVP In an effort to optimize CVP power generation capacity, this model assumes additional operational flexibility relative to Reclamation's operational studies, particularly for the Shasta and Trinity facilities.

Applications: Western last used this model in 1992 in an effort to identify additionalCVP power generation capacity that could be used to offset future shortages. No other entity has used the model.

CALFED Potential: This model functions as an optimization model rather than a typical predictive model. It is specific to the CVP system.

Documentation: Western has documentation of the most recent version of this model. Western authored this model.

Availability: This model is available through Western's Sacramento office.

Name and Resource Category: PROSYM. Power Resources Cost Production Model.

Purpose: PROSYM was designed by Henwood Energy Services Inc. as a cost production model to forecast costs associated with meeting a given demand for power under various hydrologic scenarios. The model inputs a specific level of power demand, resources and operational and regulatory constraints to determine the overall cost for a given level of power production.

Approach: PROSYM is an arithmetic accounting model of the hydroelectric generation capability of the CVP system relative to varied regulatory constraints and water supply scenarios. The model assumes specific hydrologic water year types and determines the change in cost from year type to year type to meet an anticipated power load. This information allows utilities to anticipate there power costs and to determine if any change in operation or additional facilities will be needed.

Inputs: The inputs data for the model include hydro generation data, hourly system load data, and other system generation resources. Additionally, the model has the capability to use energy capacity and project use data provided by the Project Simulation Model (PROSIM). In using the PROSYM model Western currently utilizes PROSIM data as its primary input.

Methods: This model performs mass balance calculations to determine overall energy use and energy generation at each facility. For example, in modeling the CVP system the model calculates the energy use and energy generation based on volumes of water passing through the facilities.

Results: This model is used to determine the costs of meeting a specific power demand level in a given water year and further to determine if there are any shortfalls forecasted in meeting power demands from year to year.

Applications: PROSYM is used extensively by the Western Area Power Administration (Western) to forecast hydropower generation capacity of the CVP system and to determine any shortages in CVP power generating capacity relative to Western's overall demand. From these results, Western then determines if it will need additional power supply relative to that generated by the CVP.

CALFED Potential: PROSYM is applicable to CALFED impact assessment. It is useful in projecting CVP system wide conditions and is also used by numerous utilities in a more site-specific environment. This model could be linked with other potential CALFED tools.

Documentation:. Henwood Energy Services Incorporated has documentation for the most recent version of PROSYM.

Availability: Henwood Energy Systems Incorporated developed PROSYM for commercial use. Locally, Western currently uses the model extensively in the CVP area.

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Name and Resource Category: PROJUSE. Project Energy Use Model.

Purpose: Reclamation developed PROJUSE to project the monthly and annual energy use of the CVP system based on varied hydrologic and regulatory scenarios. This model takes the projected water supply deliveries to the districts within the CVP system on a monthly and annual basis and calculates their energy and power use. This information is used as part of Reclamation's CVP Repayment Study.

Approach: PROJUSE assumes future CVP deliveries based on 70 year hydrologic record, factors in projected M&I, agricultural and refuge demands and then calculates the projected energy requirements associated with these deliveries. This approach provides reclamation with an overall estimate of the energy required for delivering to districts contracted to receive CVP water.

Inputs: The input data used in this model is monthly flow and reservoir storage data.

Methods: PROJUSE is an arithmetic model that uses projected water supply delivery volumes for the CVP and calculates associated energy requirements. The model uses equations tht describe energy production from reservoirs and assumptions by facilities.

Results: This model provides projections of energy use for districts receiving water from the CVP on an annual basis.

Applications: PROJUSE is now used exclusively by Reclamation to forecast energy requirements within the CVP system. For its Repayment Study, Reclamation uses the model to predict energy CVP energy requirements for a period of 10 and 20 years into the future.

CALFED Potential: PROJUSE is designed to forecast energy requirements for districts within the CVP system and is not linked to any SWP or other facilities. It is useful in describing specific conditions in the CVP and could be linked with other tools for impact assessment.

Documentation: Reclamation has documentation of the most recent version of the PROJUSE model.

Availability: PROJUSE is available from the U.S. Bureau of Reclamation, Mid-Pacific Regional office in Sacramento, CA or from the Reclamation home page on the internet.

Tool & Category:	**IMPLAN**	**Regional Economic Models**

Purpose: Estimates total change in value of regional output, income and employment associated with a change in final demand.

Approach: Input-output (IO) models consider backward economic linkages caused by the purchase of inputs by regional industries and the expenditure of personal income within the regional economy. Purchases of goods and services from outside of the region, called final demands, drive the economy. Consecutive rounds of re-expenditure create the familiar economic multipliers. IO models use dollar transactions among sectors of an economy (i.e., the dollar value of goods and services) as data.

IMPLAN is a database and method of creating IO models originally developed by the U.S. Forest Service. The database includes dollar value of output, income and employment by county, and the method generates a regional transactions matrix by use of a national average technology matrix.

Inputs: Changes in final demand of goods and services; underlying data can be modified as needed.

Methods: Input-output, a deterministic simulation.

Results: Regional change in output, income and employment.

Applications: Numerous including CVPIA PEIS, CVPIA Water Augmentation Study.

CALFED Potential: Shows one form of economic linkage between direct effects and other sectors.

Documentation: Comes with proprietary software.

Availability: Proprietary software available from Minnesota IMPLAN group (612) 779-6638.

Tool & Category:	**RIMS**	**Regional Economic Modeling System**

Purpose:	Estimate total change in regional output, income and employment caused by a change in final demand.
Approach:	RIMS is an input-output (IO) modeling database developed and maintained by the Bureau of Economic Analysis (BEA), U.S. Dept. of Commerce. IO is used to estimate secondary impacts on income and employment arising from a change in final demands such as exports. Consecutive rounds of re-expenditure create the familiar economic multipliers. IO models use dollar transactions among sectors of an economy (i.e., the value of goods and services bought and sold) as data, and calculates multipliers for regional income and employment. BEA provides the multipliers for a user-defined grouping of counties.
Inputs:	Change in final demand.
Methods:	Input-output, a deterministic calculation.
Results:	Change in regional value of output, income and employment.
Applications:	Numerous.
CALFED Potential:	Shows economic linkages between direct effects and other sectors.
Documentation:	Available from BEA.
Availability:	BEA charges a fee to calculate and provide multipliers. Fee varies based on region of analysis.

Tool & Category:	**Economic Risk Model (ERM)** **M&I Water Economics**
Purpose:	Developed by the Department of Water Resources to simulate drought water management activities and costs within the service area of the Metropolitan Water District of Southern California (MWD).
Approach:	The ERM estimates shortage costs based on annual time series of water deliveries. The model was recently enhanced by Foster Associates, Inc., to predict shortage costs associated with changes in Mono Lake and Colorado River deliveries. The enhanced version assumes that industry is substantially protected in drought, and the model estimates economic impacts to industry and landscaping sectors. The shortage costs included in the model are based on the Carson-Mitchell contingent valuation study.
Inputs:	DWRSIM water deliveries, demand other south coast supplies.
Methods:	PASCAL simulation.
Results:	Costs of shortage and shortage programs. Does not include alternative supplies.
Applications:	The model has been applied to estimate economic value associated with new SWP water supply facilities and costs of shortage caused by reduced Mono Lake deliveries.
CALFED Potential:	Could be used to estimate shortage costs and benefits of transfers or other new water delivered to the south coast region.
Documentation:	Some documentation available from DWR.
Availability:	Public domain, requires TURBO PASCAL for uncompiled version.

Tool & Category:	**Alternative Cost Approach**	**M&I Water Economics**

Purpose:	To measure economic benefit of an action as the avoided cost of the best alternative
Approach:	This approach assumes that some action must be taken to achieve a goal. The benefit of a particular proposed action is measured as the avoided cost of the best (usually the cheapest) alternative. In some cases a number of alternatives are considered and ranked from least to most expensive. In M&I watter supply analysis water shortage and conservation programs are included as possible alternatives to a new water source and vice-versa.
Inputs:	The costs of alternative water supplies, shortages or conservation programs.
Methods:	Applied in most economic benefit/cost models. Often uses a spreadsheet.
Results:	Economic benefits and costs
Applications:	DWR's Office of Water Recycling has developed guidelines for the evaluation of reclamation projects based on this principle. The Economic Risk Model (ERM) considers the costs of shortage and the alternative costs of supplies needed to eliminate that shortage.
CALFED Potential:	Might apply data being used by DWR for Bulletin 160-93 or the Office of Water Recycling.
Documentation:	Water Resource Council 1983 Principles and Guidelines provides general guidance, other benefit-cost manuals may be more specific.
Availability:	Widely used approach; not associated with any particular model.

Tool & Category:	**Central Valley Water Municipal Use Model** **M&I Water Economics**
Purpose:	Developed for the Central Valley Project Improvement Act Programmatic EIS to estimate the economic costs and benefits of CVPIA provisions on M&I water users.
Approach:	Based on microeconomic theory and alternative cost approach. The spreadsheet model includes 10 groups of M&I providers stretching from Redding to San Diego. Water demands and supplies are based on Bulletin 160-93 and hydrologic model results. The model relies heavily on observed water price data and demand and supply elasticities from secondary sources for its economic values. In the long-run version of the model providers acquire water until demand equals supply (no permanent shortage is allowed), long-run revenues must equal costs, and any increased cost of water increases retail water prices. The acquired water can be groundwater, water transfers or other permanent supplies. Increased price reduces consumption according to the long-run elasticity of demand. A short-run version of the model is operated to represent conditions during drought. Retail water price is fixed in the short run. Drought conservation is required if shortage occurs during drought. Residential drought conservation in 2020 is limited by demand hardening, and commercial and industrial customers can be shorted only up to 5 percent of their demand. If this drought conservation does not eliminate the shortage then providers can purchase drought supplies. Drought supplies are typically more expensive than permanent supplies. The costs of drought are lost net revenues, lost consumer surplus of retail customers, costs of drought conservation programs and the costs of drought supplies..
Inputs:	Retail water demand and initial price, imported and local supplies. Amount and price of water transfers and other new supplies available.
Methods:	Spreadsheet application with simultaneous components.
Results:	Water costs and revenues, costs of additional supplies, consumer surplus loss.
Applications:	CVPIA PEIS
CALFED Potential:	Can be used to estimate economic costs of changes in M&I water supplies.
Documentation:	Under development for PEIS.
Availability:	Developed and used by CH2M HILL for USBR, Excel or Lotus 123 spreadsheet. Contact Roger Mann (916) 920-0300

Name and Resource Category: IRPSIM. Resource Planning

Purpose: The **I**ntegrated **R**esource **P**lanning **Sim**ulation model developed by Metropolitan Water District of Southern California was developed to simulate the balance of water demand and supply int its service area.

Approach: IRPSIM uses a stochastic methodology to simulate the water supply within the MWD service area. It uses discrete or continuous distributions of climate, cost, and hydrology, and provides the model user with maximum flexibility in defining the model parameters. The model is site specific to the MWD water supply system.

Inputs:

Methods: The model is stochastic and provides the user with options for structuring the analysis. The relationships defined in the model include empirical and deterministic relationships along with random error functions to define uncertainty.

Results: IRPSIM produces text files of descriptive statistics and raw results of the model, and graphical output. The user has several options for requesting the raw output.

Applications: IRPSIM is applied to the MWD water system to analyze system reliability and cost.

CALFED Potential: This model could be used to provide boundary conditions in the MWD service area to use in other, more generalized model.

Documentation: The model is documented.

Availability: The model is available from MWD.

Tool & Category:	**Central Valley Production Model (CVPM)** **Agricultural Economics**
Purpose:	Predict changes in irrigated acreage, crop production, price, value and net returns, changes in irrigation technology, from changes in costs or resource conditions such as water supply.
Approach:	Economic optimization. The model mimics the production decisions of agricultural producers (farmers) in the Central Valley of California. It assumes that farmers maximize net farm income subject to resource, technical and market constraints. The major constraints are 1) linear marginal cost functions estimated using the technique of positive mathematical programming; 2) commodity demand functions which relate market price to the total quantity produced, 3) acreage response functions which relate changes in crop acreage to changes in net returns and other cost information, 4) irrigation technology tradeoff functions which model the tradeoff between applied water and irrigation technology, and 5) a variety of constraints defining land and water resources and other legal, physical and economic limitations. The current version covers the Central Valley of California using DWR's Detailed Analysis Units and includes up to 22 crop production regions in the Central Valley and 26 types of crops. An aggregation routine is included allowing the user to consider any groupings of regions and crops. The model includes options allowing the user to specify 1995 or 2020 conditions, and short-run or long-run economic analysis corresponding to drought and average hydrology respectively. The model's database includes fixed, variable and harvest production costs and crop prices, yields and acreage from the County Agricultural Commissioners. Agricultural Census data has been used to adjust between harvested, irrigated and dryland acreage. A simple representation of federal farm programs is included.
Inputs:	Water supplies and costs, adaptable for a variety of applications.
Methods:	Positive mathematical programming and quadratic programming
Results:	Acreage, irrigation efficiency and cost, crop value and net returns.
Applications:	DWR Planning Studies, CVPIA Water Augmentation, CVPIA PEIS.
CALFED Potential:	Estimate economic impacts to agriculture and change in irrigation technology from changes in water supply, costs, regulation.
Documentation:	Draft completed in November 1994, being updated for PEIS.
Availability:	Currently being used by CH2M HILL and DWR. Will become publicly available at time of Draft PEIS for CVPIA. Requires GAMS software.

Tool & Category:	**California Agricultural Resources Model (CARM)** **Agricultural Economics**
Purpose:	Predict changes in irrigated crop production from changes in costs, input prices, or resource conditions such as water supply.
Approach:	Economic optimization. CARM was developed at the University of California as a tool to assess changes in agricultural and water policy on California agriculture. The model covers the entire state with 17 production regions and over 30 crops. CARM is a quadratic programming model that maximizes a quadratic net farm income subject to resource constraints. It was first developed in the early 1980's, with occasional but irregular updating of information. CARM incorporates crop price response information.
Inputs:	Water supplies and costs, adaptable for a variety of applications to irrigated agriculture.
Methods:	Quadratic programming.
Results:	Irrigated acreage, production, value and net returns.
Applications:	USBR Water Contracting EIS, various policy studies of water supply cost, and air pollution impacts.
CALFED Potential:	Could be used to estimate economic impacts to agriculture caused by changes in water supply.
Documentation:	Limited documentation available from Dr. Richard Howitt, University of California at Davis.
Availability:	Requires GAMS software. Several versions of the model are available from U.C., CH2M HILL and Dr. Gerald Horner.

Tool & Category:	**Central Valley Production and Transfer Model (CVPTM) Agricultural Economics**
Purpose:	Estimate water transfer amounts, prices, sources and destinations.
Approach:	Economic Optimization. The CVPTM is the Central Valley Production Model (CVPM) augmented by up to 10 urban water transfer demand regions, and includes information on water transfer feasibility, cost and conveyance loss. The CVPM estimates a net return from the use of water for irrigation. which defines the implicit supply price of water. The CVPTM adds water transfers as an economic activity and solves for the water price, crop mix, amount of irrigated land and level of water transfers that maximize the total value of water for irrigation and water transfers. Water transfer constraints in the CVPTM consider physical and institutional feasibility, loss of water in transit, physical constraints in conveyance and storage systems, and institutional requirements imposed by environmental regulations and other laws and agreements. Physical and institutional limitations are estimated from hydrology models and other information and are included in the CVPTM as mathematical constraints. The loss coefficient matrix considers water losses from three sources: the share of applied water that is not evapotranspiration and is therefore not transferable, the share of transferable water lost in conveyance, and the share of water that must be contributed to meet Bay/delta requirements. The model can include M&I water transfer demand functions from CVWMUM.
Inputs:	Water supplies, M&I water transfer demands.
Methods:	Positive mathematical programming and inter-regional trade.
Results:	Irrigated acreage, production, value and net returns, water transfers and their costs by origin and destination.
Applications:	CVPIA Programmatic EIS and Water Augmentation Program.
CALFED Potential:	Could be used to estimate cost of water bought for Delta flows and costs to irrigated agriculture.
Documentation:	Currently in development for CVPIA PEIS.
Availability:	Currently being used by CH2M HILL. Requires GAMS software. Contact Stephen Hatchett (916) 920-0300.

Tool & Category:	**Westside Agricultural Drainage Economics (WADE)** **Agricultural Economics**
Purpose:	To assess drainage control policies in the Western and Southern San Joaquin Valley.
Approach:	WADE was developed to assess drainage control policies in the Western and Southern San Joaquin Valley. The regional agricultural production module maximizes net farm income subject to water supplies, drainage conditions and other resource constraints. The model incorporates a number of irrigation technology and management levels for each crop. The crop production model is linked in six-month time steps to a groundwater model which calculates water and salt balances over time for the root zone, a shallow groundwater layer and deeper groundwater. The model is designed to simulate long-term trends in soil salinity, drainage water quality and salinity and pumping lifts. WADE includes 7 crop types and over a hundred production units.
Inputs:	Water deliveries, policy changes such as water price, drainage controls.
Methods:	Regional optimization using an integrated agricultural production-groundwater-drainage model.
Results:	Acreage, production value, net returns, volume and quality of return flows.
Applications:	Developed originally for the San Joaquin Valley Drainage Program, and subsequently modified and used for the San Luis Unit Drainage Plan.
CALFED Potential:	Could be used to assess impact of agricultural drainage controls.
Documentation:	Available from USBR or CH2M HILL
Availability:	Developed by CH2M HILL for USBR, and available from either. requires GAMS software. Contact Stephen Hatchett (916) 920-0300.

Tool & Category:	**Crop budgeting method**	**Agricultural Economics**

Purpose:	To estimate net returns to irrigated crop production. Can also be used to estimate other direct economic impacts of irrigated agriculture.
Approach:	Crop budgets use production cost, price and yield information to assess the profitability of different crops. The approach predicts which crops become more or less profitable as costs, prices, or resource conditions change. Secondary crop budget data also may include detailed information on inputs such as water, labor and farm chemicals that may be useful for hydrologic, regional economic, and water quality analyses. Crop budgeting is often used as part of data for other, more flexible analytical tools including CARM, CVPM, and other models. It can also be used to rank crops according to profitability in order to predict which crops are likely to change as water or other conditions change.
Inputs:	Production costs, yields, crop prices.
Methods:	Accounting spreadsheets or databases.
Results:	Net revenue, expenses for labor and other services.
Applications:	Commonly used by Reclamation and others to assess the economic and financial feasibility of crop production and use of water for irrigation.
CALFED Potential:	Can be used to estimate change in profitability of crops in response to water supply, regulations or other costs.
Documentation:	Typically provided with each crop budget; quality of documentation varies.
Availability:	Crop budget data are developed by and available from Reclamation, the U.C. Cooperative Extension Service, and occasionally other sources.